BBC

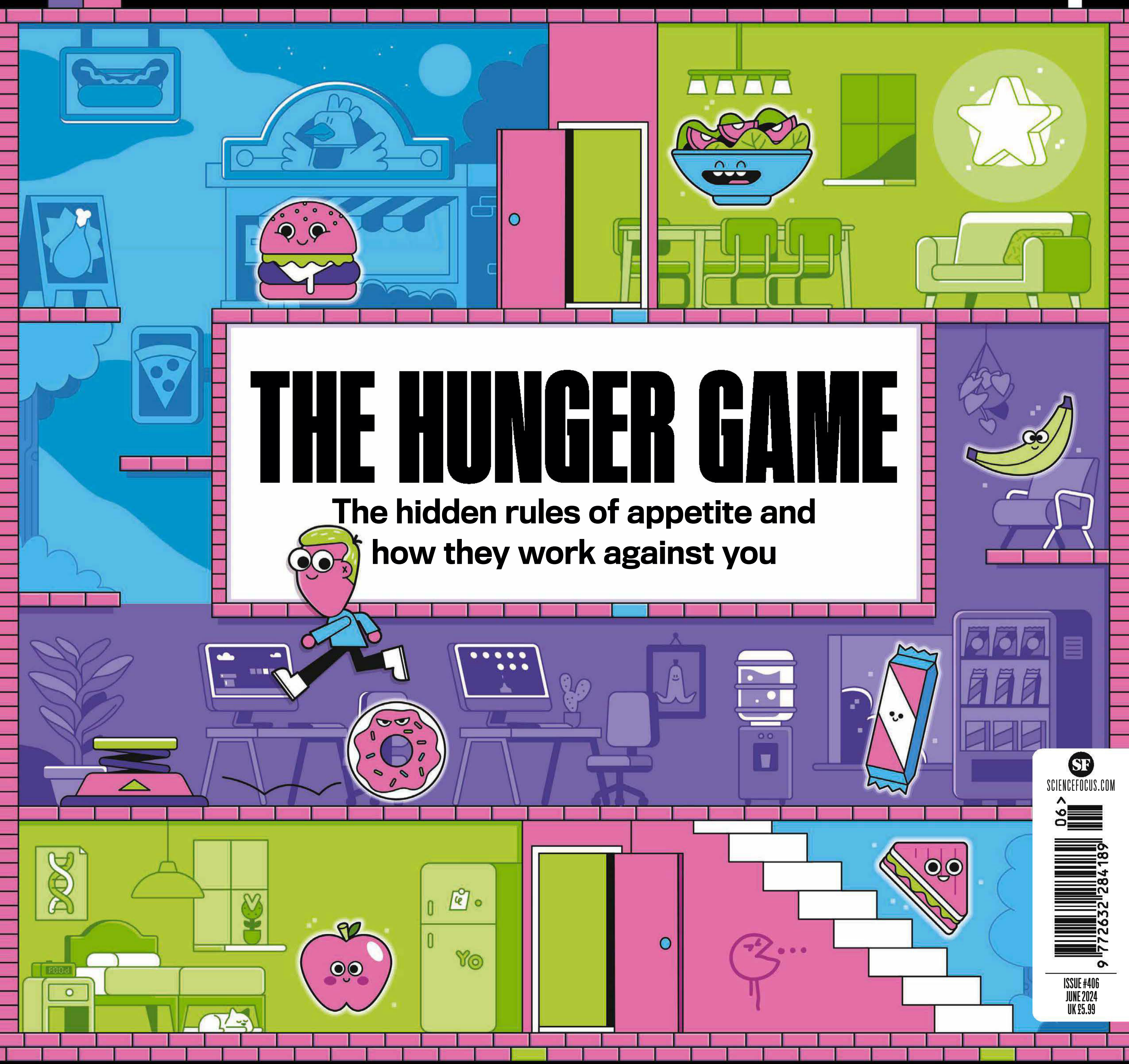
HERE'S WHAT HAPPENS AT THE END OF THE UNIVERSE

Science Focus

The search for
WHAT GRAVITY IS MADE OF

Do we need
ELECTRIC AEROPLANES?

How to
HACK YOUR MOTIVATION



THE HUNGER GAME

The hidden rules of appetite and how they work against you

SF
SCIENCEFOCUS.COM
ISSUE #406
JUNE 2024
UK £5.99

IN THIS ISSUE

Storms
How giant, rogue waves threaten our safety at sea

Physics
On the trail of nuclear forensic scientists

Health
The undiagnosed sleep disorder affecting millions

ADVERTISEMENT FEATURE

You understand the power of science. You value facts and evidence over popular opinion. Medical research is your greatest gift to future generations.

Medical Research Foundation

We need people like you – who understand the power of science – to fund the research that will change lives in the future.

By leaving a gift to the Medical Research Foundation, you'll be funding the research that future generations will depend on. The Medical Research Foundation is an independent charity, focused solely on funding quality medical research. With close links to the Medical Research Council, we're able to choose the most impactful studies and adapt quickly to meet any emerging health crisis – thanks to the support of people like you.

Your Will can support some of the brightest scientific minds.

Many of these scientists are at the beginning of their careers, when funding is hardest to secure. Your support at this critical time can provide the springboard a scientist needs to drive their research and career forward, ensuring they can continue to make life-changing discoveries for many years to come.

Thanks to gifts in Wills, the Medical Research Foundation has supported researchers tackling pressing challenges like the COVID-19 pandemic and the threat of antimicrobial resistance, as well as vital areas of research that are often overlooked by other funders – ensuring we fill the gaps in our medical knowledge and protect the future of human health.

Get your guide to gifts in Wills

We have seen how quickly global health crises can arise, and how much we depend on the brightest scientific minds to offer a way out.

As someone interested in science, you will understand that while no one can predict what we will face next, we can be certain that it is only through ambitious, high-quality medical research that we will meet whatever new challenges come our way.

By leaving a gift in your Will, you can have a lasting impact on science and on the future of human health in the UK.

@MedResFdn
@MedResFdn
Medical Research Foundation

Scan this QR code to find out more

Leave a legacy of scientific thought. Remember the Medical Research Foundation with a gift in your Will.

To request your guide to gifts in Wills fill in this form and return to The Medical Research Foundation,
99 Charterhouse Street, London, EC1M 6HR **OR** visit **medicalresearchfoundation.org.uk/support-us/wills**

Name ____________________
Address ____________________
____________________ Postcode ____________________
Email address ____________________

Medical Research Foundation

Registered with FUNDRAISING REGULATOR

We would like to contact you from time to time with our latest news. Please tick here ☐ if you are happy for us to contact you via email. We will not share your personal information. You can unsubscribe at any time. For further information on how we collect, store and process your personal data, please read our Privacy Notice medicalresearchfoundation.org.uk/privacy

0624BSF

Medical Research Foundation is a charity registered in England and Wales (Reg. Charity No. 1138223).

FROM THE EDITOR

I know it's hard to lose weight, but I didn't realise just *how* hard until Prof Giles Yeo's cover feature landed on my desk. And yes, I am overweight. Having worked with Giles in the past, and watched his films for the BBC's *Horizon*, I know my weight is anchored to my genes. Just as you could guess my height by looking at my parents, you could probably get my weight roughly right too.

But if I'm honest, I hadn't understood just how complex a system hunger really is. For one thing, the 'system' isn't actually hunger, but appetite, which encompasses hunger, fullness and reward, all of which are mediated by different parts of the brain. To complicate things further, our guts and our brains need to speak to one another, but it turns out they don't speak the same language.

The complexity of the relationship between our guts and our brains is why, despite knowing the harm obesity can cause us, it's so difficult for us to change – despite so many of the world's health influencers trying to convince you that it's just a simple decision.

And that's without getting into what's going on outside our bodies: how the world concocts all manner of treats designed to bend our brains to their will (hello, doughnuts). Then there's the marketing, conceived to seduce and trick us when we're at our weakest (hello, deliciously named doughnut shop at the train station).

Mercifully, you can head to p68 where Giles explains it all, because, after all, knowledge is power.

Daniel Bennett

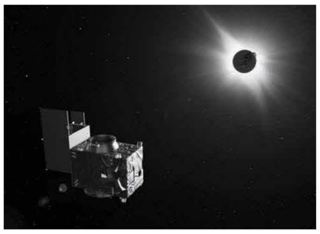
Daniel Bennett, Editor

WANT MORE? FOLLOW **SCIENCEFOCUS** ON FACEBOOK X (FORMERLY TWITTER) PINTEREST INSTAGRAM

ON THE BBC THIS MONTH...

Nature Table
A new series of the show that celebrates the eccentricities of nature's wild side, sees comedian Sue Perkins and her team of experts talk dogs, duck vaginas and a space rock that might have kickstarted life on Earth.
BBC Radio 4
Also available on BBC Sounds

Rare Earth
Helen Czerski and Tom Heap get their teeth into the biggest environmental issues affecting the planet. First on the agenda: 'greenhushing', a phenomenon where companies that once boasted about their green credentials suddenly go quiet on the issue.
BBC Radio 4
Also available on BBC Sounds



The Sky at Night
The team visit the European Space Agency to see its new Proba-3 mission, which will create eclipses on demand (something we're covering in a future issue).
Available now on BBC iPlayer

COVER: PATSWERK THIS PAGE: GETTY IMAGES, BBC, ESA/P CARRIL, GHELEYNE BASTIAEN

How close are we to being able to record our dreams? →p80

CONTRIBUTORS

DR KATIE MACK
Dark energy is already the most mysterious phenomenon in the Universe, but, as Katie explains, it keeps on baffling scientists in surprising new ways. →p30

KIMBERLY WILSON
The food we eat affects our brains as much as our bodies. Psychologist Kimberley tells us what to put on our plates to keep our grey matter in tip-top condition. →p36

DR ALASTAIR GUNN
What will be the ultimate fate of the Universe? Astronomer Alastair goes through the leading theories and explores how CERN is proposing to find out which one is right. →p62

PROF GUY LESCHZINER
With 80 per cent of people suffering from sleep apnoea currently undiagnosed, neurologist and sleep disorder expert Guy explains the signs to look out for. →p40

CONTACT US

Advertising
David.DSouza@ourmedia.co.uk
0117 300 8110

Letters for publication
reply@sciencefocus.com

Editorial enquiries
editorialenquiries@sciencefocus.com
0117 300 8755

Subscriptions
ourmediashop.com/contact-us
03330 162113*

Other contacts
sciencefocus.com/contact

---

*UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 9am-5pm. If calling from overseas, please call +44 1604 973721.

BBC Science Focus (ISSN 0966-4270) (USPS 015-160) is published 14 times a year (monthly with a Summer issue in July and a New Year issue in December) by Our Media, Eagle House, Bristol, BS1 4ST. Distributed in the US by NPS Media Group, 2 Enterprise Drive, Suite 420, Shelton, CT 06484. Periodicals postage paid at Shelton, CT and additional mailing offices. POSTMASTER: Send address changes to *BBC Science Focus*, PO Box 401 Williamsport, PA 17703.

CONTENTS

REGULARS

06 EYE OPENER
Amazing science images from around the world.

12 FEEDBACK
Your thoughts and opinions on the recent stories in *BBC Science Focus*.

15 DISCOVERIES
All the month's biggest news, including: The eczema vaccine on the horizon; Huge explosion spotted on mysterious dead star; The origins of Earth's 'second moon'; Ultra-processed foods may not be as bad for us as previously thought; And more...

30 PROF KATIE MACK
Dark energy, the most mysterious phenomenon in the entire cosmos, may have just found a new way to surprise us.

32 DR DEAN BURNETT
Why your brain doesn't suddenly mature when you turn 25.

48
SUBSCRIBE TODAY!

BBC HERE'S WHAT HAPPENS AT THE END OF THE UNIVERSE
Science Focus
THE HUNGER GAME
The hidden rules of appetite and how they work against you

Save 50 per cent on the cover price when you subscribe to *BBC Science Focus* today.

34 DR MICHELLE GRIFFIN
More and more women are opting to freeze their eggs. But just how successful is the treatment?

36 REALITY CHECK
The science behind the headlines: Can food choices really affect our brain health?; The rogue waves causing havoc for ships; And why you could have sleep apnoea and not know it.

42 INNOVATIONS
A roundup of the hottest trends in tech, including a massive power bank for doomsday preppers and AI-powered earbuds.

76 THE BIG QUESTION
What is gravity 'made of'?

80 Q&A
Our experts answer your questions. This month: How can you tell if a spider is dangerous? Why do I get so bloated? What's the best comeback to an insult? Can owning a pet really slow cognitive decline? Would a planet need a moon for life to evolve? And more...

89 CROSSWORD
Engage your grey matter!

89 NEXT MONTH
Take a sneak peek at the upcoming issue.

90 BETTER LIVING THROUGH SCIENCE
How to slow time and live more in the moment.

15
DISCOVERIES

Huge volcanic eruptions may have caused some dinosaurs to become warm-blooded and gain feathers.

36
REALITY CHECK

A balanced diet helps protect your neurological wellbeing, but which types of food are best?

80
Q&A

SWEET DREAM

FEATURES

50 TAKE-OFF AT LAST
Step into the future and take a look at the first battery-powered aircraft built for greener flying.

56 MASTER YOUR MOTIVATION
Simple, practical ways to help you end the cycle of procrastination and achieve your goals.

62 HOW THE UNIVERSE WILL END
Freeze, crunch, rip or slurp? Cosmologists are addressing one of the biggest questions of all.

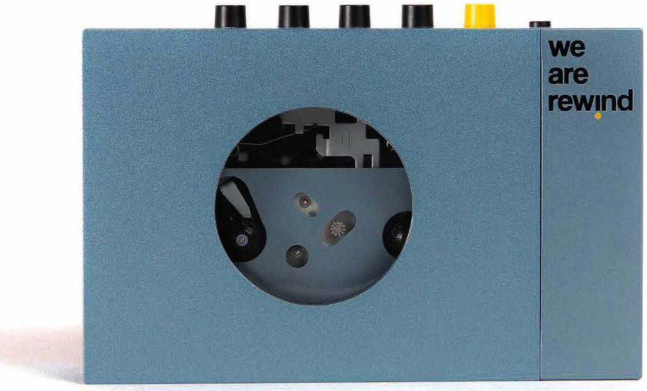
68 THE HUNGER GAME
Prof Giles Yeo delves into the reasons why it's so difficult to keep your appetite under control.

50
TAKE-OFF AT LAST

VELIS
ELECTRO
S5-PII01

42
INNOVATIONS

The greatest new gadgets, including the retro favourites making a comeback... like this reimagined walkman.



30
DR KATIE MACK

×

"DARK ENERGY ESSENTIALLY JUST BUILDS A LITTLE STRETCHINESS INTO EVERY BIT OF SPACE"

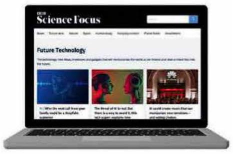
WANT MORE?

Don't forget that *BBC Science Focus* is available on all major digital platforms. We have versions for Android, as well as an iOS app for the iPad and iPhone.

Science Focus
THE HUNGER GAME
SF

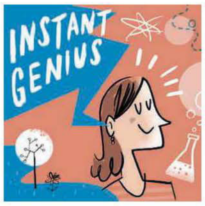
Can't wait until next month to get your fix of science and tech? Our website is packed with news, features and Q&As to keep your brain satisfied.

sciencefocus.com



INSTANT GENIUS

Our bite-sized masterclass in podcast form. Find it wherever you listen to your podcasts.



LUNCHTIME GENIUS

A DAILY DOSE OF MENTAL REFRESHMENT DELIVERED STRAIGHT TO YOUR INBOX

Sign up to discover the latest news, views and breakthroughs from the *BBC Science Focus* team

sciencefocus.com/newsletter

EYE OPENER

It *is* rocket science

NEW ORLEANS, USA

It's been over 50 years since our last visit, but humanity's return to the Moon is inching ever closer. At NASA's Michoud Assembly Facility in Louisiana, engineers are installing the first of four RS-25 engines onto the second core stage of the Space Launch System (SLS). It'll also be a return to space for the engine you see here, 'E2059', as it was previously used in five shuttle launches between 2007 and 2011 (it's had an overhaul since then).

The SLS will propel Artemis II, the first crewed mission of the programme currently planned for September 2025. The crew of four astronauts will embark on a 10-day journey around the Moon and aim to set a record for the farthest human travel from Earth by venturing 7,500km (4,600 miles) beyond its far side. This will pave the way for a Moon landing with Artemis III.

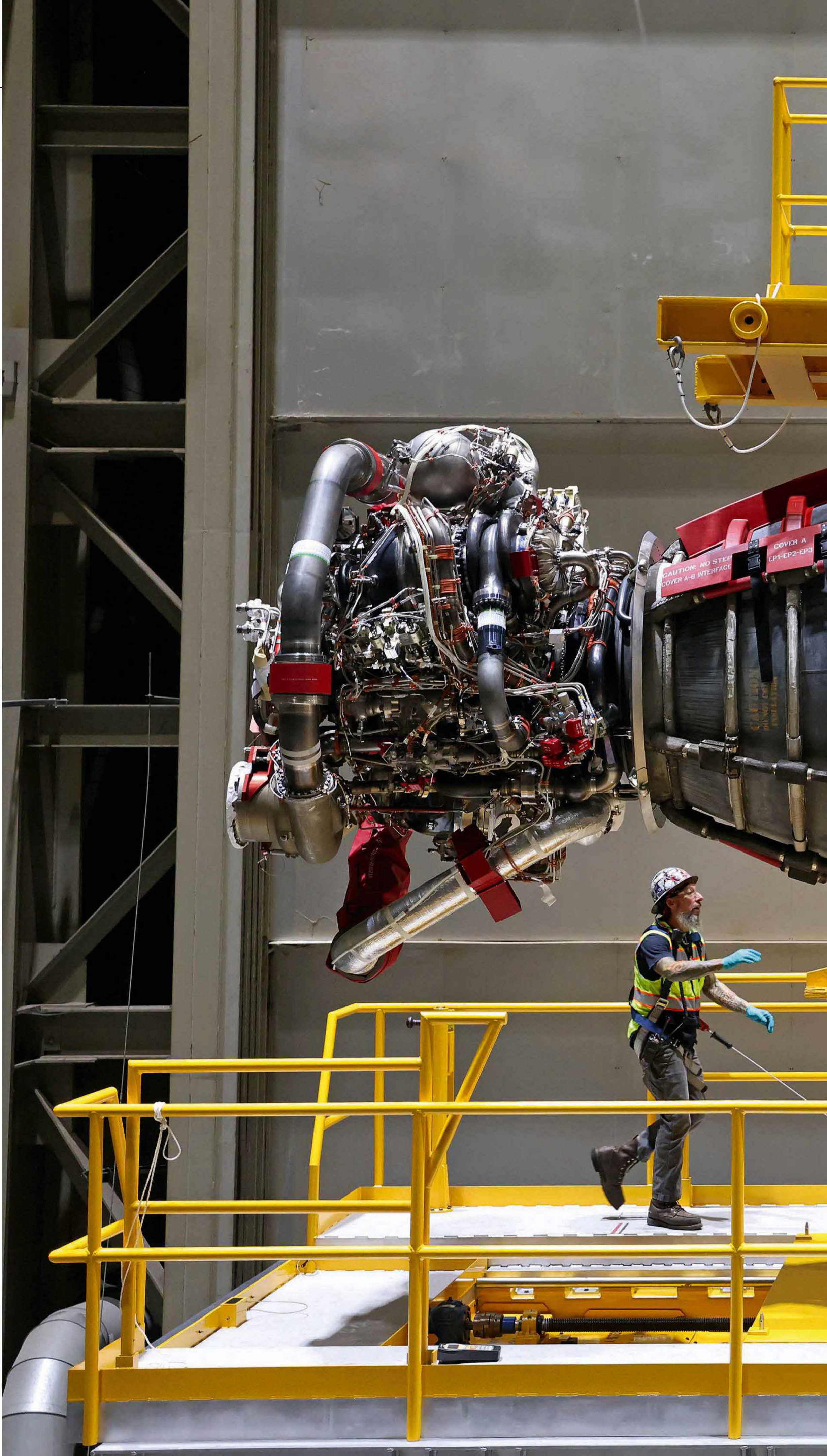
According to NASA, the RS-25 is the world's most high-performance, staged combustion engine. The four being installed for Artemis II will burn over 2.8 million litres (730,000 gallons) of super-cooled liquid hydrogen and oxygen in just eight minutes, producing the required thrust to get the astronauts into orbit.

NASA

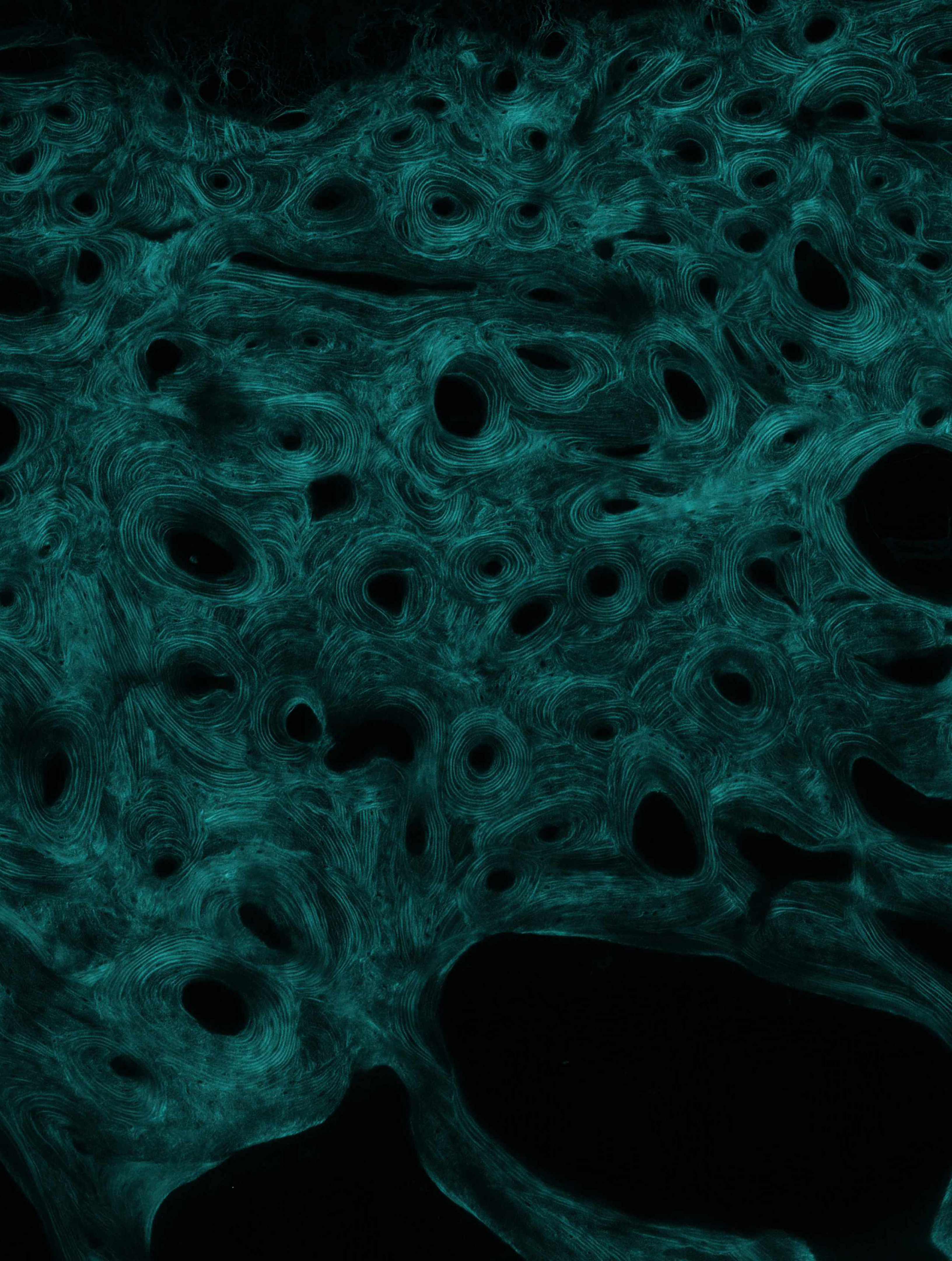
VISIT US FOR MORE AMAZING IMAGES:

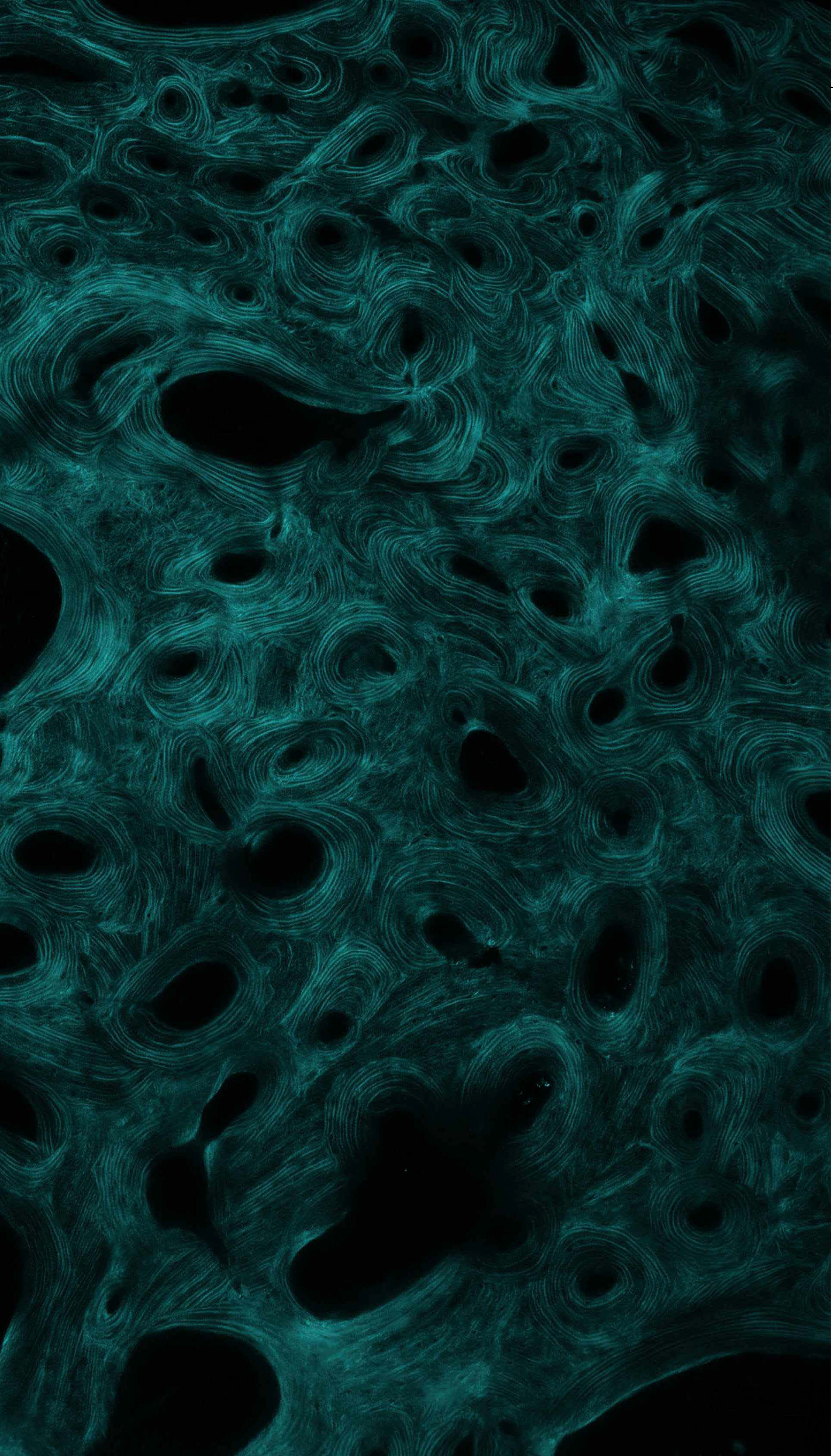
SCIENCEFOCUS

BBCSCIENCEFOCUS



CAP. 17,000
SLING ASST ENGINE CARRIER
CAUTION DO NOT CRUSH INSULATION
HORIZONTAL ENGINE INSTALLER





EYE OPENER

Down to the bone

ZURICH, SWITZERLAND

This is neither a contour map of strange, underground lakes nor the swirling diffusion of a toxic gas. It's the inside of a human bone – a cortical bone from the femoral neck at the top of the femur, to be exact.

The blueish lines show the structural units that make up bone, known as mineralised collagen fibrils and lamellae, while the black pools are the canals of soft tissues and blood vessels that deliver vital nutrients to the bone cells.

The image was captured at ScopeM at ETH Zurich with second-harmonic generation (SHG) microscopy. SHG analysis can identify what standard imaging can't, such as the structure of collagen.

New imaging like this will improve our understanding of the bone structure in healthy, diseased and treated tissues, says Enrico Dall'Ara, professor of musculoskeletal biomechanics at the University of Sheffield. "They can tell us about how tissues form, develop and adapt to different external stimuli through the activities of the cells."

Researchers hope SHG microscopy will advance treatments for bone fragility as we age, including predicting a patient's fracture risk.

TATIANA KOCHETKOVA/SNSF COMPETITION

VISIT US FOR MORE AMAZING IMAGES:

SCIENCEFOCUS

BBCSCIENCEFOCUS

EYE OPENER

All systems go (nearly)

ABU DHABI, UAE

Formula 1 is a sport all about experimentation and fine-tuning, whether it's the regular switching of tyres or meticulously tweaking a car's aerodynamic design. A recent event in Abu Dhabi, however, introduced a more drastic step: removing drivers from the race entirely.

The first autonomous racing league race got underway at the Yas Marina Circuit in April. With no drivers, but a whole lot of computing power, four AI-controlled F1 cars took to the track, including the eventual winner from Team TUM (Technical University of Munich) seen here.

Rather than changing the mechanical performance of the identical cars, teams from Italy and Germany focused on the software algorithms. But while it marked a step forward in driverless technology, it would be generous to say the event signalled the immediate future of motor racing. Only four of the intended 10 teams made it to the start line and the race was hit with issues: cars randomly stopped on the track or went into a spin for no reason. One even drove into a wall while speeding along a straight during practice.

REUTERS

VISIT US FOR MORE AMAZING IMAGES:

SCIENCEFOCUS

BBCSCIENCEFOCUS

TUM
33
MOBILITY TECHNOLOGY CENTER
INONET
TWAICE
ADNOC
MASDAR
MUBADALA
dallara
LIVE FIVE
KISTLER

EVUM MOTORS
FERNRIDE
A2RL
du BUSINESS الأعمال
aws

FEEDBACK

YOUR OPINIONS ON SCIENCE, TECHNOLOGY AND OUR MAGAZINE

@ reply@sciencefocus.com

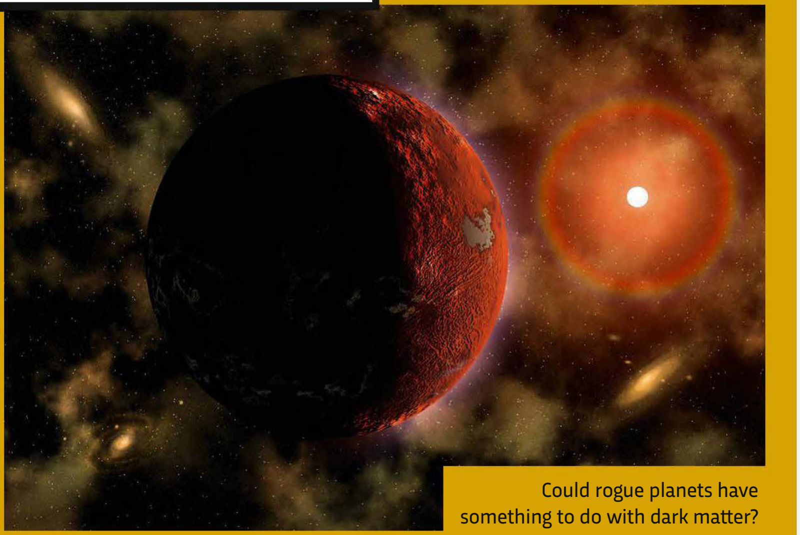
✉ *BBC Science Focus*, Eagle House,
Bristol, BS1 4ST

𝕏 @sciencefocus

f www.facebook.com/sciencefocus

@bbcsciencefocus

LETTER OF THE MONTH



Could rogue planets have something to do with dark matter?

A possible explanation?

I've just finished reading Colin Stuart's feature 'Going Rogue' (April, p63). He mentions that when the Nancy Grace Roman Space Telescope is launched by NASA in 2027, the total estimate of free-floating worlds in the Milky Way may be boosted from billions to trillions. Should this come to pass, I wonder what proportion of mass this would represent for our galaxy. If one were to apply this information to the known Universe, would it answer our questions about dark matter?

Tom Jones, via email

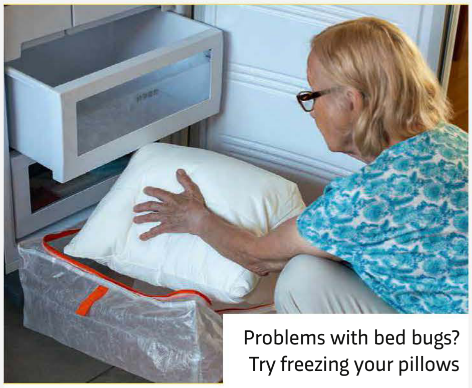
Colin Stuart replies: *The idea of lots of hidden objects adding up together to account for dark matter isn't new. It usually goes by the name of MACHOs (Massive Compact Halo Objects). But even a 1,000x increase in the total rogue planet population's mass wouldn't make enough of a dent to account for dark matter. A trillion Earths represent just 0.002 per cent of the Milky Way's total mass. Dark matter seems to outnumber ordinary matter by almost six to one, so we'd still be missing a significant chunk.*

WRITE IN AND WIN!

The writer of next issue's Letter of the Month wins a pair of **hardback popular science books**. Put pen to paper (or fingertips to keyboard) and you could get your hands on *The Biggest Ideas in the Universe Vol. 2* by Sean Carroll and *Space Oddities* by Harry Cliff.

WORTH OVER £35

THE BIGGEST IDEAS IN THE UNIVERSE
quanta and fields
SEAN CARROLL
Space Oddities
HARRY CLIFF



Problems with bed bugs? Try freezing your pillows

Freeze the bed bugs out

I thought Sofia Quaglia covered the problem of bed bugs comprehensively (April, p55). One method of controlling them that I've found to be very effective wasn't mentioned, though: the use of a freezer.

Bed bugs often stray no further than the pillow, so putting your pillow in a plastic bag and placing it in a freezer will kill any bed bugs present. Sheets can also be put in a freezer, as can dirty clothes prior to washing (people don't always wash at a temperature hot enough to kill the bugs, resulting in clean laundry that's still home to dead bugs). Sleeping bags – another place bed bugs like to hide – can be similarly frozen.

While freezing won't deal with ingrained bed bug infestations, it's an easy option that doesn't rely on insecticides and all their unwanted effects. And if one freeze doesn't work, you can easily repeat the process – especially if any eggs survive the first freeze.

Dr Roger Webber, via email

Neuromodulation isn't new

The sort of neuromodulation devices covered in your Innovations article (April, p41) aren't new and have been around for a very long time in the form of transcutaneous electrical nerve stimulation (TENS) machines. They typically cost between £20-30 and deliver electric pulses at various intensities and

“IT’S IMPORTANT TO REMEMBER THAT BRAIN DEVELOPMENT ISN’T LIKE BUILDING A HOUSE”

DR DEAN BURNETT, p32

speeds depending on use. I’ve used one for many years mainly to control back pain, which it does very well with no side effects.

Ron Cattell, via email

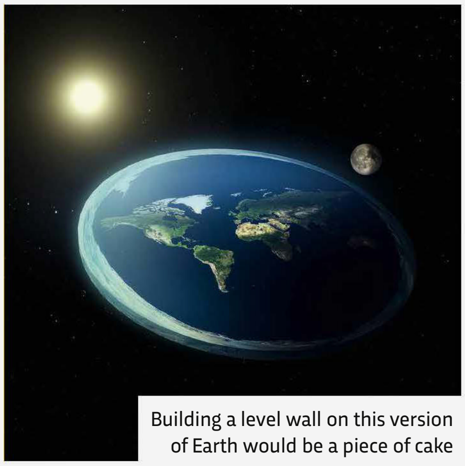
Dr Simon Thomson, consultant in pain management and neuromodulation, and founder of the Neuromodulation Society of UK and Ireland replies: *Neuromodulation is a collective term for many different devices and targets for nerve stimulation. Stimulating the vagus nerve produces different effects in several conditions. TENS stimulates some sensory nerve endings in the skin and can be used to modulate back pain. Different conditions need different types of nerve stimulation.*

Flat Earth idea hits a brick wall

The section about the fallacy of a flat Earth (February, p73) reminded me of two things. One was my uncle. He was a bricklayer and told me how he appreciated the curvature of Earth when building a wall. If the wall was long enough, he said, by the time you got to the end of it, it would be off a plumb line by about an inch due to Earth’s surface curve.

The other was a TV series in which Prof Steven Hawking demonstrated science. In one episode he talked about measuring the curve of Earth across a large lake in Nevada. A laser was set up on the shore, about 3ft (around 1m) above the level of the water, and aimed out across the lake. People on a boat floating 3 miles (almost 5km) away then measured the height of the laser beam and found it was about 6ft (almost 2m) above the water. I remember watching this and being amazed at how quickly the horizon falls away from a straight line – almost as amazed as I was by the perfection pursued by bricklayers.

George Robinson, via email



Building a level wall on this version of Earth would be a piece of cake

GETTY IMAGES X3

Clarification, please?

One of my pet hates is the presentation of statistics, as in your article on time-restricted eating (April, p26), which states that it could increase a person’s risk of death from cardiovascular disease “by a staggering 91 per cent.” But we’re not told how big the risk was to start with! If the risk was one per cent and it increases to two per cent, that’s a 100 per cent increase, but not as worrying as if the risk increased from 50 to 100 per cent, which is also a 100 per cent increase. Please always give us the absolute figures for such comparisons.

John Gribbin, via email

BBC Science Focus replies: *The World Health Organization marks cardiovascular diseases as the leading cause of death globally, representing 32 per cent of all deaths in 2019. Of those, 85 per cent were due to a heart attack or stroke. So, it seems, a 91 per cent increase in that risk might be worth paying attention to.*

But it’s important to note that the findings of the study that linked time-restricted eating to a higher risk of cardiovascular death are preliminary and haven’t undergone peer review. The researchers advise caution, emphasising that an association doesn’t equal causation. So, for now, it’s probably okay to skip breakfast if you’re thinking of following a time-restricted eating plan, but check with your doctor, first.

THE TEAM

EDITORIAL
Editor & brand lead Daniel Bennett
Managing editor Robert Banino
Commissioning editor Jason Goodyer
Digital editor Thomas Ling
News editor Noa Leach
Trends editor Tom Howarth
Staff writers Alex Hughes, Holly Spanner

ART
Art editor Joe Eden
Picture & asset manager James Cutmore

CONTRIBUTORS
Olga Aleksandrova, Gheleyne Bastiaen, Hayley Bennett, Peter Bentley, Dean Burnett, Marcus Chown, Emma Davies, Russell Deeks,Michelle Griffin, Alastair Gunn, Rachel Hathaway, Matt Holland, Christian Jarrett, Pete Lawrence, Guy Leschziner, Katie Mack, Nish Manek, Rosanna Morris, Patswerk, Helen Pilcher, Jenny Price, Emmanuel Santos, Kyle Smart, Joel Snape, Ian Taylor, Luis Villazon, Jonathan Wilkes, Kimberley Wilson, Giles Yeo and all the folks at VMG Digital.

ADVERTISING & MARKETING
Business development manager David D’Souza
Newstrade manager John Lawton
Subscriptions director Jacky Perales-Morris
Direct marketing manager Kellie Lane

TECHNOLOGY
Senior Marketing Manager – Digital Editions
Kevin Slaughter
Tech director Azir Razzak

INSERTS
Laurence Robertson 00353 876 902208

LICENSING & SYNDICATION
Director of International and Licensing Tim Hudson
Head of Licensing Tom Shaw
Head of Syndication Richard Bentley

CONTENT OPERATIONS
Content operations, procurement & sustainability director Sarah Powell
Group content operations & sustainability manager
Louisa Moulter
Content operations coordinator Lauren Morris
Ad services manager Paul Thornton
Ad designer Camilla Owen

PUBLISHING
CEO Andy Marshall
Managing director Andrew Davies

BBC STUDIOS, UK PUBLISHING
Chair, editorial review boards Nicholas Brett
Managing director, consumer products and licensing
Stephen Davies
Global director, magazines Mandy Thwaites
Compliance manager Cameron McEwan
UK.Publishing@bbc.com
www.bbcstudios.com

EDITORIAL COMPLAINTS
editorialcomplaints@ourmedia.co.uk

ANNUAL SUBSCRIPTION RATES (INC P&P):
UK/BFPO £83.86; Europe & Eire €114;
Rest of World $137

Audit Bureau of
Circulations 132,360
(combined, Jan-Dec 2023)

BBC Science Focus Magazine is published by Our Media Ltd, under licence from BBC Studios who help fund new BBC programmes.

© Our Media Ltd 2024. All rights reserved. Printed by William Gibbons Ltd.

Our Media Ltd accepts no responsibility in respect of products or services obtained through advertisements carried in this magazine.

Our Media Company is working to ensure that all of its paper comes from well-managed, FSC®-certified forests and other controlled sources. This magazine is printed on Forest Stewardship Council® (FSC®) certified paper. This magazine can be recycled, for use in newspapers and packaging. Please remove any gifts, samples or wrapping and dispose of them at your local collection point.

This was Sylvia's promise to you...

A generation ago, a woman named Sylvia made a promise. As a doctor's secretary, she'd watched stroke destroy the lives of so many people. She was determined to make sure we could all live in a world where we're far less likely to lose our lives to stroke.

She kept her promise, and a gift to the Stroke Association was included in her Will. Sylvia's gift helped fund the work that made sure many more of us survive stroke now than did in her lifetime.

Sylvia changed the story for us all. Now it's our turn to change the story for those who'll come after us.

Stroke still shatters lives and tears families apart. And for so many survivors the road to recovery is still long and desperately lonely. If you or someone you love has been affected by stroke – you'll know just what that means.

But it doesn't have to be like this. You can change the story, just like Sylvia did, with a gift in your Will. All it takes is a promise.

You can promise future generations a world where researchers discover new treatments and surgeries and every single stroke survivor has the best care, rehabilitation and support network possible, to help them rebuild their lives.

Will you make that promise to generations to come? Please, leave a gift in your Will to the Stroke Association.

Find out how by calling 020 7566 1505
or email legacy@stroke.org.uk
or visit stroke.org.uk/legacy

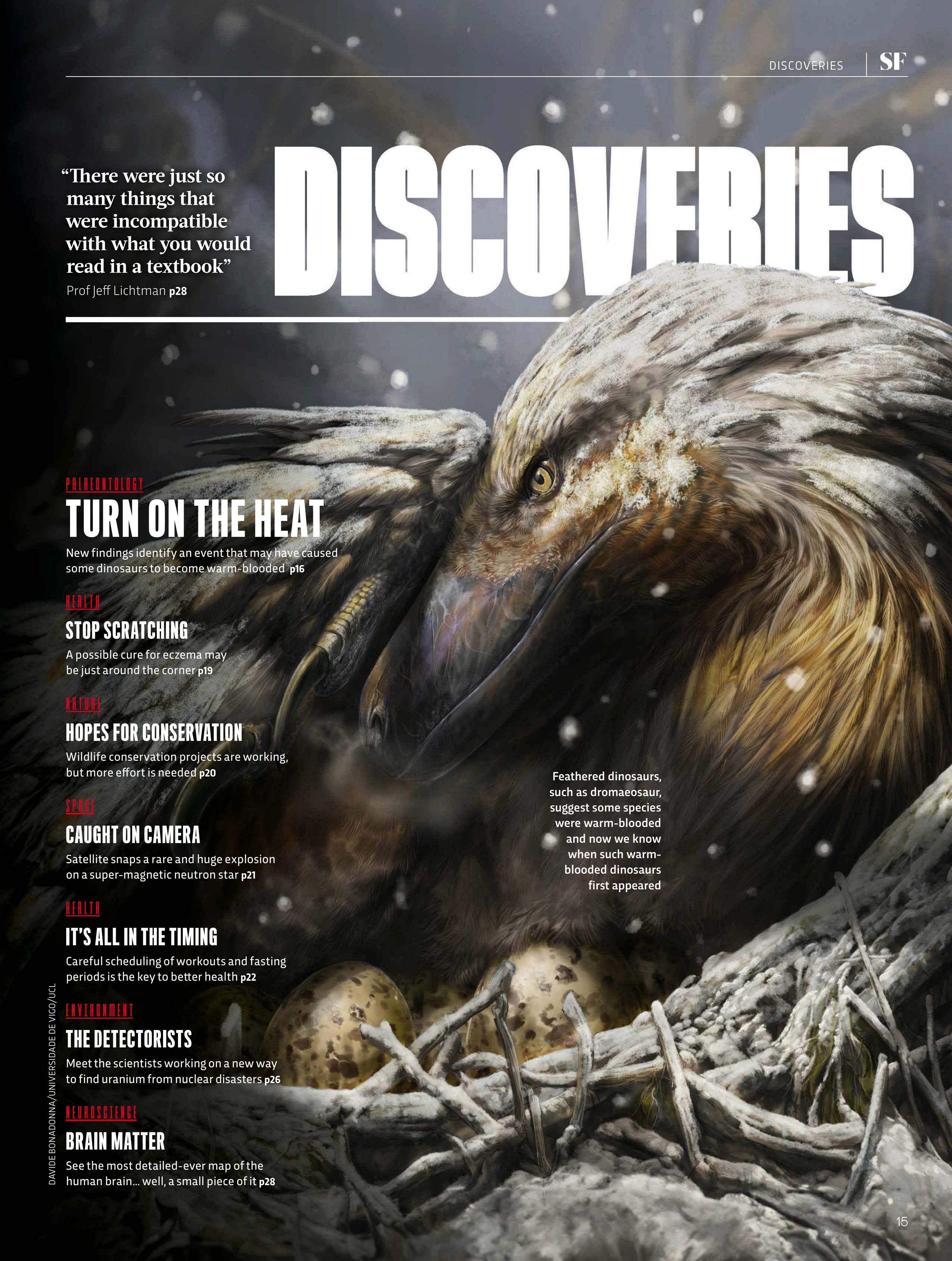
Rebuilding lives after stroke

The Stroke Association is registered as a charity in England and Wales (No 211015) and in Scotland (SC037789). Also registered in the Isle of Man (No. 945) and Jersey (NPO 369), and operating as a charity in Northern Ireland.

Stroke Association

DISCOVERIES

> "There were just so many things that were incompatible with what you would read in a textbook"
> Prof Jeff Lichtman **p28**



Feathered dinosaurs, such as dromaeosaur, suggest some species were warm-blooded and now we know when such warm-blooded dinosaurs first appeared

PALAEONTOLOGY

TURN ON THE HEAT

New findings identify an event that may have caused some dinosaurs to become warm-blooded **p16**

HEALTH

STOP SCRATCHING

A possible cure for eczema may be just around the corner **p19**

NATURE

HOPES FOR CONSERVATION

Wildlife conservation projects are working, but more effort is needed **p20**

SPACE

CAUGHT ON CAMERA

Satellite snaps a rare and huge explosion on a super-magnetic neutron star **p21**

HEALTH

IT'S ALL IN THE TIMING

Careful scheduling of workouts and fasting periods is the key to better health **p22**

ENVIRONMENT

THE DETECTORISTS

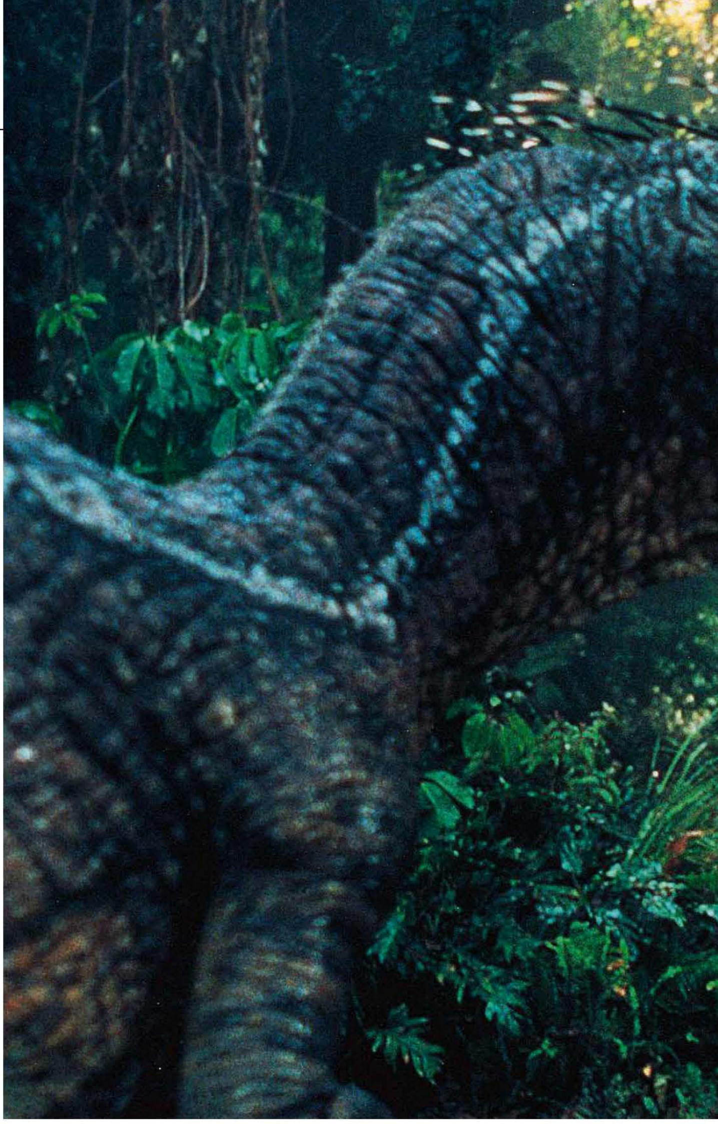
Meet the scientists working on a new way to find uranium from nuclear disasters **p26**

NEUROSCIENCE

BRAIN MATTER

See the most detailed-ever map of the human brain… well, a small piece of it **p28**

DAVIDE BONADONNA/UNIVERSIDADE DE VIGO/UCL



PALAEONTOLOGY

DINOSAURS BECAME WARM-BLOODED AFTER WORLDWIDE VOLCANIC ERUPTIONS, FINDS BREAKTHROUGH STUDY

Prehistoric global warming may have forced an evolutionary change… and it could help reveal the impact of the current climate crisis

If you've ever found the evolutionary journey from dinosaur to chicken a little hard to imagine, scientists can help, as they've just added another step on the path – and it might involve a series of colossal volcanic eruptions across the planet.

A new study, led by researchers at University College London and the University of Vigo in Spain reveals the moment, 180 million years ago, when some dinosaurs developed endothermy: the ability to regulate their body temperature and generate internal heat. This trait of being 'warm-blooded' is shared by mammals and birds today.

It's only in the last few years that research has challenged the established understanding that dinosaurs were all cold-blooded animals, like today's reptiles. The fact that some had feathers suggested they might have been endothermic. But the question of when warm-blooded dinosaurs first appeared, including the ancestors of modern-day birds, was not known – until now.

The researchers think these dinosaurs emerged in the Early Jurassic period, at a time of intense volcanic activity that forced species to adapt to climate change across the planet. The so-called 'Jenkyns Event', approximately 183 million years ago, saw lava and volcanic gasses burst through giant fissures in Earth's surface, leading to global warming and the extinction of plant groups. The study suggests that this split up the main dinosaur groups as they developed different climate preferences.

"I was surprised [by the results], particularly with the coincidence of the majority of evolutionary change at the Jenkyns Event," first author Dr Alfio

UCL, SHUTTERSTOCK

ABOVE Velociraptors on the prowl in *Jurassic Park III*, but it turns out they might not have been as cold-blooded as we thought

ABOVE LEFT Dr Alfio Alessandro Chiarenza, author of the new study, was surprised by the findings

> **“Endothermy may have allowed some dinosaurs to grow faster and produce more offspring”**

Alessandro Chiarenza told *BBC Science Focus*. “This is a relatively newly recognised hyperthermal (global warming) event in our geologic record and the fact that it might have had such an influence on global ecosystems, and also have affected the evolution of dinosaurs, is quite a new concept.”

Published in the journal *Current Biology*, the study analysed the spread of dinosaurs across different climates during the Mesozoic era (230-66 million years ago) through 1,000 fossils, climate models, geography and evolutionary trees.

Researchers discovered that two of the three main dinosaur groups moved to colder climates during the Early Jurassic and adapted with endothermy. These were theropods (which include *Tyrannosaurus rex* and *Velociraptor*) and ornithischians (with relatives of *Stegosaurus* and *Triceratops*). The third group, sauropods (the family of massive dinosaurs that includes *Brontosaurus* and *Diplodocus*), stuck to warmer areas and remained cold-blooded.

Endothermy may have allowed theropods and ornithischians to grow faster, produce more offspring and sustain physical activity for longer. These benefits may have helped their lineages survive through environmental degradation; despite global warming, the polar regions were still dark for about four months a year.

Meanwhile, the researchers think the sauropods thrived in arid environments, where their large, cold-blooded bodies could store the warmth that they needed. “The bigger your water pot is, the slower it cools down. That’s what we think sauropods were doing,” says Chiarenza.

Discovering how changes in the climate affected the evolution of the dinosaurs could shed light on how the current climate crisis is affecting today’s species, the researchers think.

“Another reason to investigate and better understand global warming events in our geologic past is to understand what effects they may have on biodiversity,” says Chiarenza. “A lesson from the deep past for our future.”

leger
HOLIDAYS

DISCOVER THE VERY BEST OF EUROPE

ON A FULLY ESCORTED COACH HOLIDAY

Everything is taken care of when you choose a holiday with Leger, with 100s of tours to choose from and prices from only £399pp.

EXPERIENCED
DRIVERS

It starts with a local pick-up – there are hundreds of points across the UK. Your experienced driver takes it from there and will be with you every step of the way. Sharing tips and advice, there's always someone on hand! You're never alone on a Leger holiday...

LUXURY COACH
TRAVEL

Travel by luxury coach with state-of-the-art Luxuria. Exclusive to Leger Holidays and the business class of coaches, sink into your deluxe, armchair-style seat, unwind with a vast choice of entertainment on your personal touch-screen TV, and enjoy more space around you with only 31 seats.

EXPERTLY PLANNED
ITINERARIES

We'll cross the best Europe has to offer, so don't forget the cameras! Travelling by coach means you'll take in sights along the way that you wouldn't otherwise see... the rolling countryside, the spectacular landscapes, the traditional towns along the way – this is what the others miss!

KNOWLEDGEABLE
GUIDES

From start to finish, we've got you covered... food, drinks, hotels, itineraries: sorted. Once there, our specially selected, knowledgeable guides ensure you won't miss a thing! Every trip, every historic detail... and by the end of your holiday, you'll be an expert too.

THE GOOD
COMPANY

Travelling in the comfort of a group of like-minded people, you're in good company with Leger. Soak up the relaxing, sociable atmopshere, enjoy new experiences, share stories, create unforgettable memories, and you may even make friends for life!

"A combination of a first-rate tour guide, well organised coach crew, very full and informative itinerary, and great company made this tour one to remember" – **Geoff Mould**

Trustpilot ★★★★★
Rated **'Excellent'**

COMBINING STATE-OF-THE-ART COACH TRAVEL WITH SOME OF EUROPE'S MOST FASCINATINGLY UNIQUE HOTELS, THESE HOLIDAYS OFFER A TRULY SPECTACULAR EXPERIENCE.

01709 914 880
leger.co.uk/signature

ABTA
ABTA No.V3582

T&Cs apply.

MULTI-AWARD WINNING COMPANY
BRITISH TRAVEL AWARDS 2023

SCAN ME

leger
HOLIDAYS
EUROPE
& WORLDWIDE
FULLY ESCORTED HOLIDAYS

018093

HEALTH

IT MAY SOON BE POSSIBLE TO END ECZEMA WITH A VACCINE

By treating eczema-based flare-ups in children, researchers think they're closer to soothing this common skin problem

One in five children suffers from atopic eczema (the type related to allergies). For half of those children, the skin condition will last for life. Eczema, while not life-threatening or contagious, can cause serious discomfort, especially in younger years, with common symptoms including itchy and dry skin and, when bacteria are involved, weeping wounds that can lead to infections.

A new vaccine could soon prevent it from happening, however. Researchers from Trinity College Dublin have identified how flare-ups of bacteria-driven eczema impact the immune system. A vaccine could bolster the immune system and limit the severity of eczema, as well as reduce the need for antibiotics. It may even treat other atopic diseases, such as hay fever and asthma.

Examining a total of 93 children aged from 0–16 years, researchers compared the immune responses of three groups: those with eczema with a skin infection, those with eczema without infection, and a healthy group of volunteers.

They then identified the 'immune signatures' of children with infected flare-ups of eczema, which are critical to vaccine design. Researchers discovered that the proportion of T cells (cells that normally drive an effective immune response) changed noticeably between the groups. The eczema with a skin infection group showed signs that the T cells had been suppressed.

While further work is needed, study author Prof Alan Irvine said: "We believe that a more comprehensive understanding of the immune response to this bacteria in eczema has significant potential to revolutionise treatment approaches."

GETTY IMAGES X2

ENVIRONMENT

EARTHQUAKE 'SWARMS' CAUSED BY SNOW AND RAINFALL

Increased water may be affecting fluid pressure in the Earth's cracks… and climate change will make it worse

When it comes to identifying the cause of earthquakes, you may think you're on solid ground (excuse the pun) by first setting your sights below the ground. According to new research, however, you probably should be looking up to the sky.

Scientists at MIT have published findings in the journal *Science Advances* which suggest that increased heavy snowfall and rain linked to climate change could contribute to earthquakes around the world. It follows their investigation into seismic activity in Japan's Noto Peninsula, which has been hit by hundreds of earthquakes in recent years, including a magnitude 7.6 earthquake in January 2024.

A new 'swarm' of earthquakes – a pattern of multiple and ongoing quakes – is thought to have begun in northern Japan in 2020. Along with their colleagues in Japan, the MIT team tried to identify the causes contributing to this swarm. What they found was that, while those before 2020 appeared sporadic and unrelated, the timing of subsequent quakes was strongly linked to weather conditions, especially intense snowfall.

The study suggests that snow and rainwater could affect the underground 'pore fluid pressure' – the amount of pressure exerted by fluids inside cracks in Earth's bedrock. This, in turn, can have a major impact on how fast seismic waves travel underground.

The team believes that climate change could have a major impact on the planet's earthquakes in the near future. "If we're going into a climate that's changing, with more extreme precipitation events, and we expect a redistribution of water in the atmosphere, oceans and continents, that'll change how Earth's crust is loaded and will have an impact for sure," said Dr William Frank, the study's author.

NATURE

WILDLIFE CONSERVATION CAN WORK, SAYS MAJOR NEW STUDY… BUT 'TIME IS RUNNING OUT'

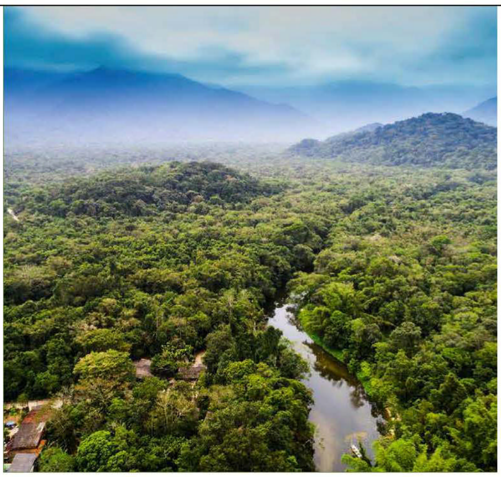
A large review of conservation studies found that efforts have made a real difference in protecting the planet's biological diversity. But others say we haven't done enough

A watershed review into whether wildlife conservation projects around the world actually work has found success in two-thirds of cases. However, conservationists such as wildlife presenter Chris Packham have warned that much more work is needed in order to prevent mass extinctions.

The review, the first of its kind, found that global conservation projects had an overall positive impact on biodiversity: the measure of how much variety in living species there is in a given area. However, the analysis also found that conservation actions will need to be vastly scaled up if we truly want to make a difference in tackling the biodiversity crisis.

"It's important to celebrate success," Packham told *BBC Science Focus*. "But at the same time, one of the reasons I would argue we haven't done enough is that we've been too timid. We've been asking politely rather than demanding forthrightly. Now we're running out of time." The study,

> "Actions will need to be vastly scaled up if we truly want to make a difference in tackling the biodiversity crisis"



Conservation projects show most success when they focus on targeted species and their ecosystems

published in the journal *Science*, involved scientists from universities and institutions around the world, including the International Union for Conservation of Nature (IUCN). To evaluate the overall impact of conservation work, they considered 186 conservation projects, from local to continental scales, with a measurable impact. They collected and standardised data on biodiversity levels before and after the projects.

The most successful conservation, they found, targeted species and ecosystems. These efforts included projects like invasive species control, reducing habitat loss and restoring habitats, protecting areas and managing ecosystems sustainably.

Here, 'success' meant either improving biodiversity or at least slowing down its decline. In some cases, conservation even prevented species extinctions.

Many international conservation goals have yet to be met, but the new study argues this is because researchers haven't previously understood what the impact of wildlife conservation may be. Knowing whether current conservation methods are successful could help to create more accurate targets.

While celebrations for individual species and local areas may be in order, the researchers say the scale of conservation must be significantly increased, "particularly beyond the traditional conservation sector," if we're going to reverse the global biodiversity crisis. Threats to species have been caused by human-induced climate change, habitat destruction and pollution.

"While we've been charting these catastrophic declines, we have also been putting together this toolkit for recovery," Packham said. "But as the paper very poignantly and pertinently points out, we simply haven't been doing it rapidly and broadly enough. That's the bottom line."

GETTY IMAGES X2, NASA/HUBBLE SPACE TELESCOPE

SPACE

MASSIVE EXPLOSION SPOTTED ON MYSTERIOUS DEAD STAR

A satellite in the right place at the right time captured an important cosmic sight

With so many wonders spread out in space, it's daunting to think how much is happening when no one is looking. That's why astronomers were thrilled when a satellite happened to be looking in just the right direction as a rare explosion in space occurred.

The giant eruption lit up a whole galaxy, known as M82, 12 million light-years away from Earth. Thinking two colliding neutron stars caused the explosion, astronomers searched for an afterglow, but there wasn't one. They realised this intense gamma-ray burst must have come from a single, mega-powerful neutron star. Neutron stars are the remains of massive stars, eight times larger than our Sun, after they explode in a supernova. Instead of turning into a black hole, the remains form compact spheres with strong magnetic fields.

But the observed neutron star's magnetic fields were super-strong, making it a magnetar, an extremely magnetic neutron star. With magnetic fields over 10,000 times stronger than average neutron stars, magnetars have the strongest magnetic fields measured in the Universe and emit energy through giant flares. It was one of these flares that ESA's satellite INTEGRAL happened to capture last November. The burst only lasted one-tenth of a second, but within 13 seconds a gamma-ray burst alert was sent to astronomers worldwide.

"We immediately realised that this was a special alert. Gamma-ray bursts come from far away and anywhere in the sky, but this burst came from a bright, nearby galaxy," said Dr Sandro Mereghetti of the National Institute for Astrophysics, Italy, lead author of the study published in the journal *Nature*.

Mereghetti's team took ground- and space-based telescope observations straightaway, but they didn't pick up any signals of visible light, X-rays, or gravitational waves. INTEGRAL had captured a unique and transient moment that left no traces.

Without these traces, the most likely answer behind the explosion is the mega-magnetic neutron explanation – making this the first confirmed magnetar flare outside the Milky Way. In the past 50 years, scientists have identified only three giant flares as originating from a magnetar in our galaxy.

HEALTH

INTERMITTENT FASTING AND CORRECTLY TIMED WORKOUTS ARE KEY TO FAT LOSS, SAYS STUDY

A new approach to dieting and exercise could help you lose weight and enhance your health

A new study has not only found that time-restricted eating is most effective when combined with high-intensity exercise, but also that the timing of these two approaches could enhance their benefits.

Time-restricted diets limit when, but not what, you eat. In the study, published in the journal *PLOS ONE*, this counted as eating within an eight-hour window and then fasting for 16 hours. High-intensity functional training (HIFT), meanwhile, combines aerobic and resistance exercise in repeated sets.

The research team from the University of Sfax, Tunisia, found that women with obesity had an improved body composition and cardiometabolic health after completing a 12-week programme where these two methods were combined. Crucially, the exercise took place just after the eating period had ended. “Combining exercise (or simply physical activity) and diet is the best strategy to improve metabolic health, irrespective of weight loss,” nutritionist Dr Adam Collins, who was not involved in the study, told *BBC Science Focus*. “I think this could be further enhanced by looking at the timing of eating around exercise, too.”

For the study, the scientists assigned 64 obese women aged between 22 and 42 years to one of three programmes. These were: time-restricted eating only, high-intensity exercise only, and a combination of both.

The high-intensity exercise elements took the form of three 45–55 minute workouts per week at 5pm (for those on time-restricted diets, this was the start of their fasting period). After the 12 weeks, the scientists measured the impacts on cholesterol levels, blood glucose and lipid levels, as well as other markers of cardiometabolic health.

The results? All three groups saw significant weight loss and decreases in waist and hip circumferences – as well as healthier lipid and glucose levels. But those in the combined diet and exercise group saw bigger changes – and the researchers think this approach could be easier to commit to in the long term.

SPACE

ORIGIN OF EARTH'S ‘SECOND MOON' DISCOVERED

Asteroid sampling mission will confirm whether moon-like Kamoʻoalewa came from our Moon

If you were told that the Moon we see in our night sky isn’t Earth’s only one, you’d probably be a bit surprised. But some people have started to call the strange object that seems to orbit our planet, Earth’s ‘second moon’ – and now scientists may have discovered where it came from.

In fact, there are many moon-like objects around us in space, but only a handful of the over 200,000 ‘near-Earth asteroids’ (NEAs) have similar orbits to Earth.

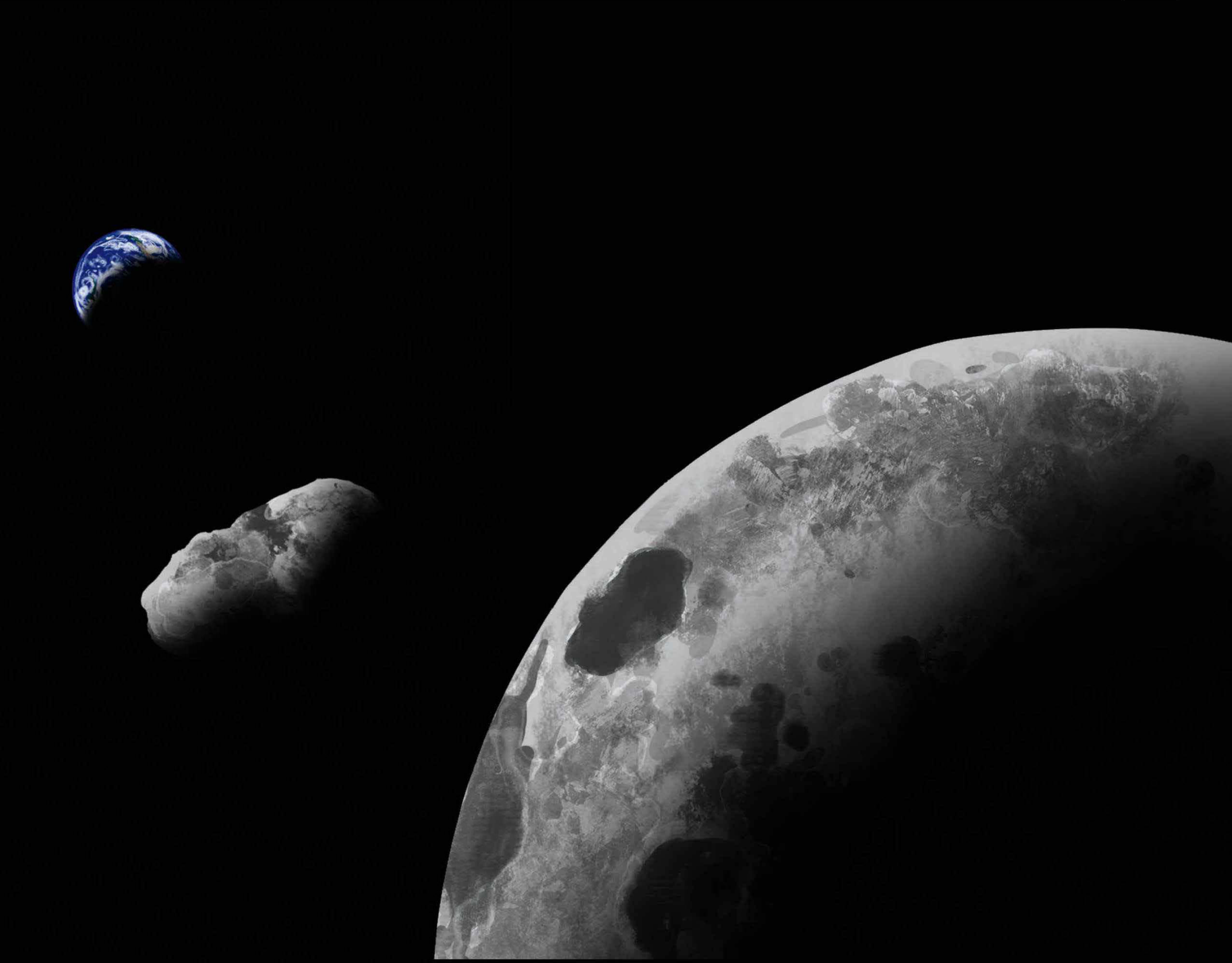
One of these, named 469219 Kamoʻoalewa, orbits the Sun, but moves in sync with our orbit so appears to orbit the Earth. This makes it our ‘quasi-moon’ or, to some, an ‘Apollo asteroid.’ Potentially as big as the Statue of Liberty, Kamoʻoalewa is between 40 and 100m (131–328 feet) across and rotates quickly: completing one rotation every 28 minutes.

Generally, NEAs are space rocks that scientists think have come from the Main Asteroid Belt between Mars and Jupiter. But new research reveals Kamoʻoalewa may be more moon than asteroid.

Published in the journal *Nature Astronomy*, the new study used existing analysis of Kamoʻoalewa’s light spectrum. This analysis revealed that it had silicates (a type of mineral) that are more common in lunar samples. In other words, Earth’s ‘second moon’ probably came from its first.

The research team from Tsinghua University, China, used computer model simulations to test this theory. They found that Kamoʻoalewa’s physical shape and orbit fitted with it being a fragment chipped off in a massive impact that

GETTY IMAGES, ADDY GRAHAM/UNIVERSITY OF ARIZONA



“They found that Kamoʻoalewa’s physical shape and orbit fitted with it being a fragment chipped off in a massive impact that caused a crater on the far side of the Moon”

caused a crater on the far side of the Moon. Specifically, they have matched the timeline of the collision to a 21km-wide (13-mile) crater named Giordano Bruno.

Everything we know about Kamoʻoalewa so far has come from ground-based observations. But in 2025, the quasi-moon will be the target of China’s asteroid sampling mission Tianwen-2, which might confirm the results. Still, Kamoʻoalewa is not technically Earth’s second moon. “While the term quasi-moon helps us appreciate the origin of these small fragments, they have no effect on us and are completely different to other moons in our Solar System,” astronomer Dr Darren Baskill, who was not involved in the study, told *BBC Science Focus*. “The Earth could have millions of quasi-moons, if we include all the small fragments that have been ejected into space by such collisions.”

ABOVE Using existing research combined with computer modelling, astronomers are closer to knowing exactly where the ‘quasi-moon’ Kamoʻoalewa came from

HEALTH

MAJOR STUDY SHOWS HOW ULTRA-PROCESSED FOODS CHANGE YOUR LIFESPAN, IF YOU'RE NOT EATING YOUR VEG

While ultra-processed food is bad for your health, a decades-long study suggests it may not be as harmful as previously thought

Everywhere you look, there are either constant warnings about the health risks associated with eating too many ultra-processed foods (UPFs), or constant temptations to eat them anyway. But while condemned by those promoting a healthy lifestyle, UPFs may be less important to your lifespan than the quality of your diet overall, according to a Harvard University study three decades in the making.

Published in the *British Medical Journal*, the research claims that consuming a large amount of UPF is linked to a four-per-cent higher risk of death from all causes. UPFs often include additives like colouring and flavours, and are typically high in energy, sugar, fat and salt, without the benefits of vitamins or fibre. Certain foods can negatively impact your health more than others, with the worst being ready-to-eat meat, poultry and seafood products, along with fizzy drinks, dairy-based desserts and highly processed breakfast foods such as sugary cereals.

> “A higher quality of overall diet may be more important than the quantity of UPFs you eat”

Over 34 years, researchers tracked the health of nearly 75,000 women and nearly 40,000 men in the US. Every two years these people reported on their health; and every four years they completed a detailed diet questionnaire.

The research team split the participants into quarters depending on their consumption of UPFs: the lowest quarter consumed about three UPF servings per day while the highest quarter ate seven UPFs per day. They discovered that those in the top quarter had a four-per-cent higher risk of all deaths. There was also a nine-per-cent higher risk of death by specific causes, such as neurodegenerative diseases like dementia.

Crucially, the study found that the link between UPF consumption and death was weakened when they factored in overall diet. This means a higher quality of diet (for example, one containing lots of vegetables, fruits, legumes and wholegrain items) may be more important than the quantity of UPFs you eat.

The researchers say that you don’t need to restrict all UPFs, just those that most affect your long-term health.

“It might not be as simple as those who ate more ultra-processed foods were more likely to die earlier,” says dietitian Dr Duane Mellor, who wasn’t involved in the study. “It’s quite possible that these foods might displace healthier foods from the diet.”

ENJOY
YOURSELF

ON A PREMIUM VALUE CRUISE

AMBASSADOR™
CRUISE LINE

THE BEST VALUE AT SEA

SAY HELLO AT
ambassadorcruiseline.com
Call 0808 102 8320

Discover our flagship, Ambience

BRONZE
BRITISH TRAVEL AWARDS 21/22
BEST CRUISE LINE FOR NO-FLY CRUISE HOLIDAYS

cruisecritic EDITORS' PICKS 2022
Best Value for Money (Ocean)

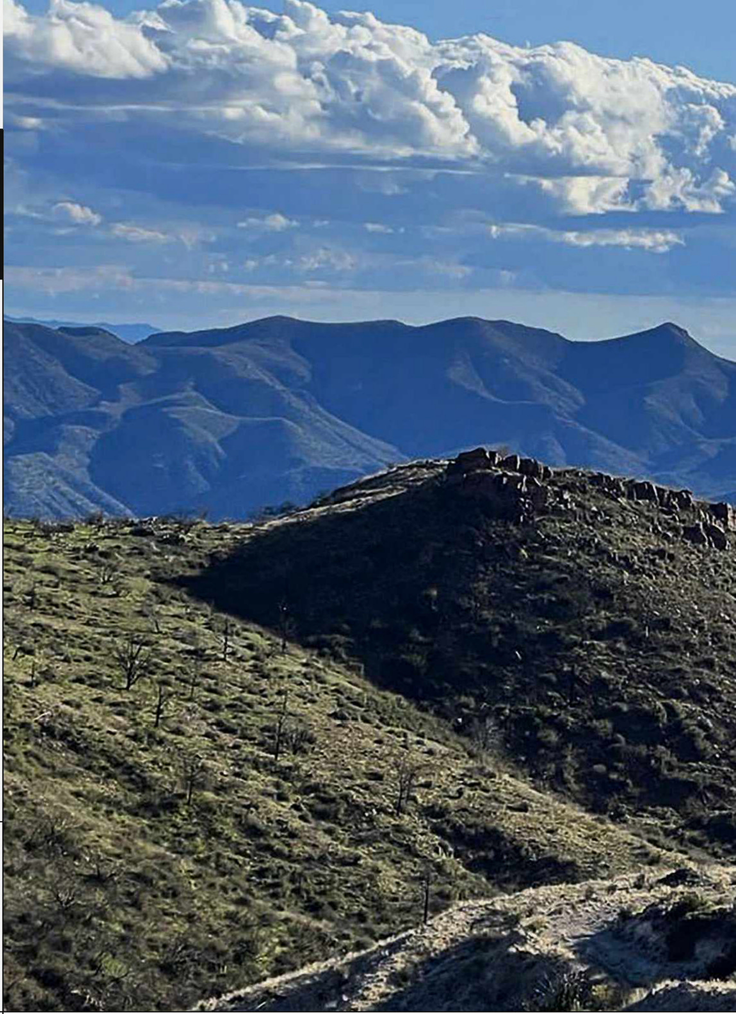
CRUISERS' CHOICE cruisecritic 2023
Best UK Mid-Size Cruises Overall

SILVER TRAVEL AWARDS 2023
WINNER

feefo ★★★★★ 4.7/5
Service Rating 1,846 Reviews

ABTA
ABTA No. Y6765

NEWS FEATURE



HOW THE LATEST DEVELOPMENT IN NUCLEAR FORENSICS MAY HELP CLEAN UP CHERNOBYL

Contrary to popular belief, radioactive material doesn't glow. But a team of nuclear forensics experts are working on a device to make it do just that. *BBC Science Focus*'s Noa Leach meets the scientists behind the innovative device

Deep in the basement of the physics department at the University of Bristol, Dr Dave Megson-Smith is telling me about how much he dislikes wearing a hazmat suit whenever he goes to Chernobyl.

"Once you get in the field, you just start sweating," says the nuclear physicist. "And suddenly, you're far less aware of your surroundings. You're less safe."

Standing next to Megson-Smith, his colleague Dr Yannick Verbelen adds: "You're tucked into plastic and you're perspiring. It's already a stressful environment because there's radiation around and you don't want to linger too much."

As we talk in the basement, I'm getting an inkling of what that's like. Granted, we're wearing thin blue lab coats rather than hazmat suits, but the heat emanating from the large machines whirring away around us makes it easier to understand the feeling of not wanting to linger. Adding to this is the fact that some of the machines also contain tiny specks of radioactive material, brought back from nuclear sites.

Megson-Smith and Verbelen specialise in disaster response and clean-up operations, carrying out what they call 'nuclear forensics': gathering radioactive samples from disaster zones to analyse in their lab. With these, they hope to extract information such as whether the sample (usually no bigger than a grain of sand) came from fallout or a nuclear fusion reactor.

Their current focus, however, is on making it easier to identify radioactive material in disaster zones. And the idea they've come up with is to make it glow a luminous yellow-green with a new contraption that they've dubbed the 'Dark Star.'

FROM A SAFE DISTANCE

Instead of relying on Geiger counters, and their frantic ticking familiar from so many films, Dark Star will detect uranium with an ultraviolet (UV) light camera that may end up attached to a drone or robot. The major advantage of a visual sensor, such as this, is that scientists can conduct radioactive monitoring from a safe distance and limit their risk of exposure.

> "The major advantage of a visual sensor, such as this, is that scientists can conduct radioactive monitoring from a safe distance and limit their risk of exposure"

The Dark Star is the world's most powerful UV fluorescence imaging device. 'Star' refers to its incredibly intense light, while 'Dark' alludes to the fact that the light is invisible to the human eye. It has been designed to be autonomous, calibrating itself to the environment, illuminating any radioactive material and recording the data – all while the scientists remain out of harm's way. Geiger counters tend to be handheld and generally have to be used at close quarters. They also only tell you that radioactive material is nearby and don't specifically locate it.

THOMAS B SCOTT, PAMELA BURNLEY, EWAN WOODBRIDGE

CLOCKWISE FROM TOP A drone surveys the Arizona landscape to correlate the terrain with the Dark Star readings taken in the mines below; the uranium is revealed in all its luminous glory thanks to the Dark Star's powerful UV light; members of the nuclear forensics team during the Dark Star tests in March this year

Megson-Smith, Verbelen and their small project team made a breakthrough with the technology in March, when they travelled to the abandoned Cold War-era uranium mines in the deserts of Arizona, USA, and carried out tests.

The team is already internationally recognised for using robotics to track the spread and risk of radioactive incidents. When a lorry travelling across Western Australia in January 2023 dropped a radioactive capsule strong enough to kill someone in a few hours if touched, the team was kept on standby to find it. The capsule was the size of your smallest fingernail.

When it comes to the Dark Star, it's essentially a highly sophisticated sensor system – not unlike an expensive digital camera, but one that can take pictures of things that we can't see.

"In contrast to what we've been made to believe by *The Simpsons*, uranium doesn't actually glow in the dark. It's just a heavy metal that's not too dissimilar to lead, albeit slightly radioactive," says Verbelen.

"However, when uranium is exposed to water and air in the natural environment, it 'rusts' and forms uranium oxides. When those oxides combine with other elements, they form minerals that do glow in the dark – with a little bit of help."

This help is what the scientists call 'stimulated fluorescence.' When the uranium absorbs another type of radiation – in this case, UV light – it emits light in response, which we perceive as a glow.

It's not as straightforward as shining a UV lamp on the radioactive material, though. "To make uranium minerals glow by fluorescence, a UV light source is needed that is orders of magnitude more powerful than the one used to check for counterfeit money in a supermarket," Verbelen explains. "And there are no power sockets in abandoned uranium mines to plug the light sources into. How do we solve this problem? That's where the Dark Star comes in." The device is powered by a rechargeable lithium-ion battery and can be deployed on a standard camera tripod.

SAFETY SHADES

The fluorescence that the Dark Star produces is certainly powerful. According to the scientists, it's enough to bathe the Arizona mines in an eerie glow. It does pose its own dangers, however. Direct exposure to it would give you the equivalent of sunburn. Even just the tiny bits of scattered UV light reflected off the mines' walls can damage your eyesight.

So although hazmat suits aren't needed, the nuclear forensics team do have to wear sunglasses. This makes for an odd look when working deep underground: "If anyone saw us, without a doubt, they would assume we're crazy," Verbelen jokes.

Dark Star will soon return to the Arizona mines, this time to be fitted to drones and walking robots. The mines are a good place to test the equipment for potential use in places like Chernobyl and Fukushima, "where it definitely wouldn't be safe to stand around," says Verbelen.

For now, though, hazmat suits remain the required uniform for trips to danger zones. Yet, both Megson-Smith and Verbelen emphasise that radiation isn't something to be scared of. They're exposed to more radiation flying over the North Pole on each trip to the US than they are in the uranium mines. A small amount of fear indicates you're being sensible and thinking about risks, says Megson-Smith, before Verbelen adds: "But you don't have to be scared if you know what you're doing. That's why Dark Star is so important. We're now able to see the radioactive material from a distance of 3–10m (10–33ft) away. We don't have to stand right next to the material anymore."

NEUROSCIENCE

INSIDE THE 3D, NANOSCALE ATLAS THAT REVEALS A FRACTION OF THE HUMAN BRAIN

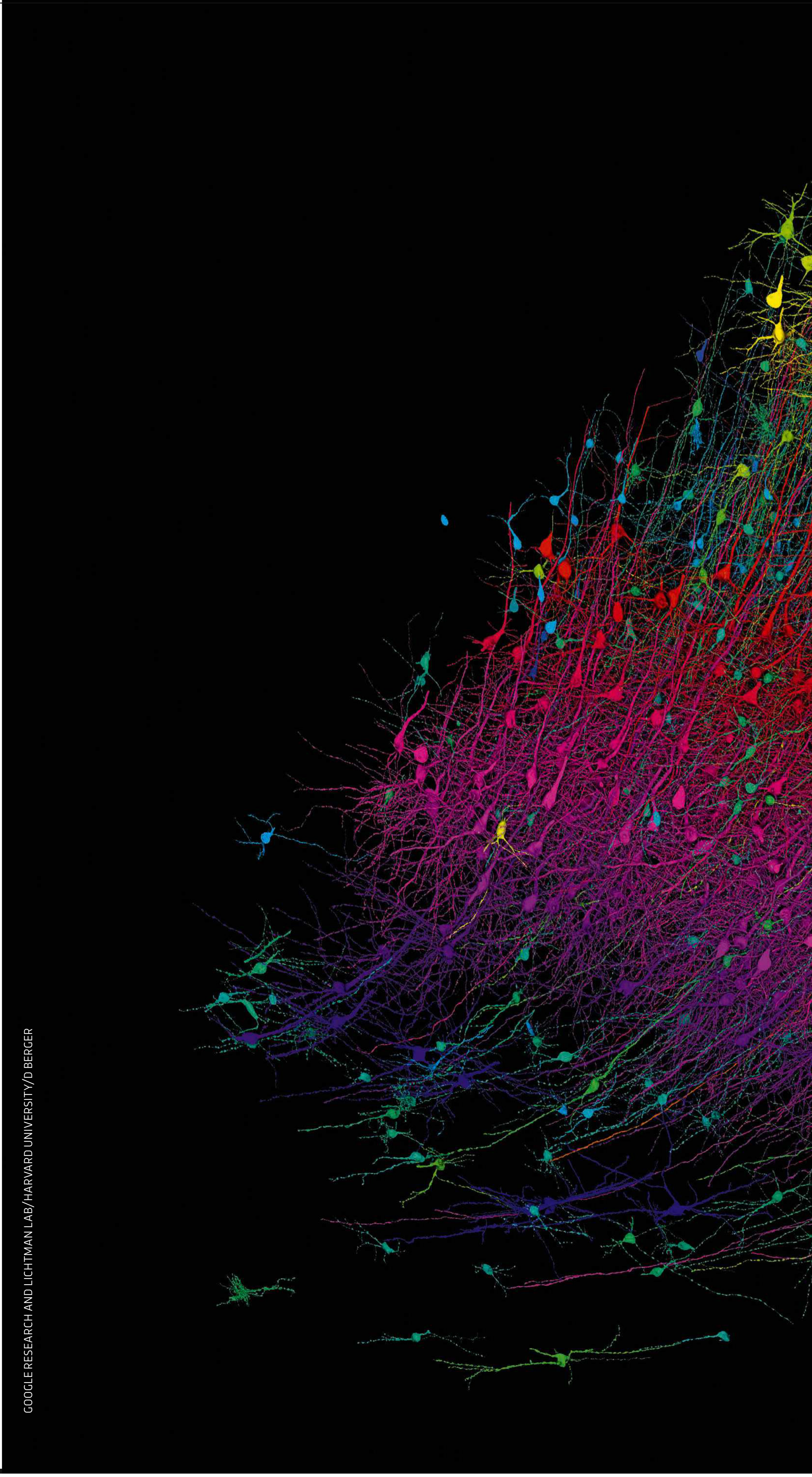
The map is now the highest-resolution picture of the human brain ever created

Five thousand slices of brain, each the width one-thousandth the thickness of a human hair, individually scanned. That's what it took to make this image: a micro-atlas of the human brain. In just a single cubic millimetre, it contains 57,000 cells, 230 millimetres of blood vessels and almost 150 million synapses.

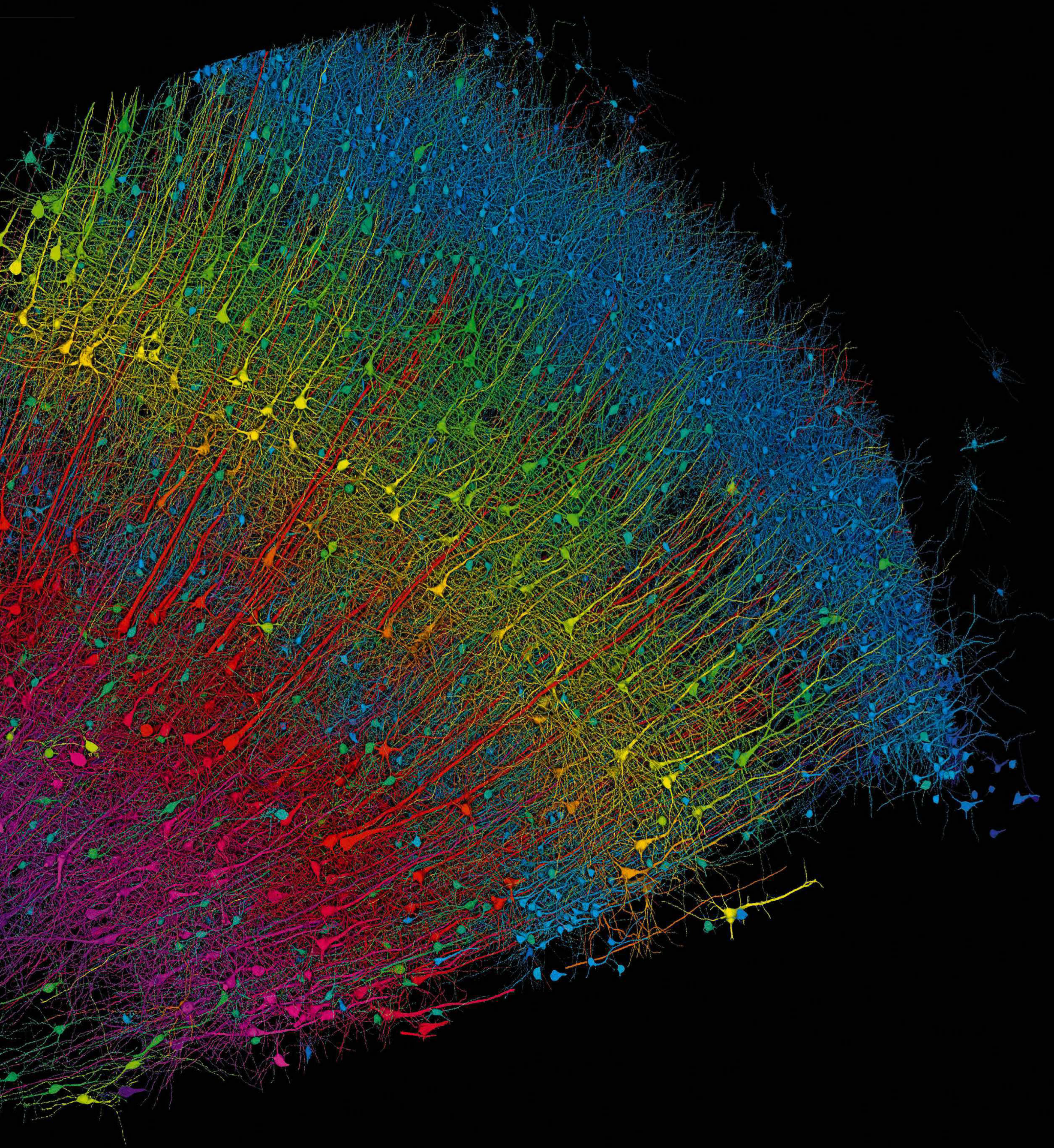
The team behind the image, from Harvard University and Google, obtained the live tissue from a woman's brain as she had surgery to control her epileptic seizures, before cutting it into slices. The team then scanned each wafer with a high-speed electron microscope, and used a machine-learning model to stitch the 5,000 scans together to form the image.

A mammoth computational challenge, the images took up 1.4 petabytes of data. That's the equivalent of streaming 14,000 full-length, 4K-resolution films. And already, the resolution of the map is revealing flaws in current neuroscientific thinking, say the researchers. "There were just so many things in it that were incompatible with what you would read in a textbook," said one of the project's lead neuroscientists, Prof Jeff Lichtman.

Next, rather than mapping the entire human brain – requiring, besides immense computational capacity, an *entire* brain from a live donor – the researchers plan to reconstruct an entire mouse brain.



GOOGLE RESEARCH AND LICHTMAN LAB/HARVARD UNIVERSITY/D BERGER



The brain atlas reveals the depth of neurons from the surface of the brain. Blue neurons are shallower, while the pink neurons are in the innermost layer

COMMENT

DARK ENERGY MIGHT BE ABOUT TO THROW A SPANNER IN THE WORKS

The most mysterious phenomenon in the Universe could be about to spring another surprise on us

It takes some hubris to name a new project the Dark Energy Spectroscopic Instrument (DESI). After all, dark energy is completely invisible – it gives off no light to be collected and analysed with a spectrograph. In fact, it's never been seen at all – it has evaded every attempt we've made to image or capture it with even our most advanced telescopes and detector experiments.

As far as we can tell, dark energy is something that is indiscernible, perfectly uniform throughout space and has no interaction at all with matter or light. Its only function, through some as-yet-undetermined mechanism, is to make space expand ever faster.

So how is it, then, that DESI's just-announced first data release is, as promised, shaking up our understanding of dark energy?

There are only a few observational handles we can get on something as frustratingly elusive as dark energy. Since all dark energy does is stretch spacetime, testing different theories of dark energy's nature involves learning how that stretching has occurred across cosmic time. One method is charting the expansion history of the Universe; a related method is to look at how quickly matter built up into galaxies and clusters at different points in our cosmic past.

Measuring the expansion rate generally relies on creating extremely precise 3D maps of matter in the cosmos; charting out lots of distant galaxies, quasars (the bright emission from the vicinity of supermassive black holes) or intergalactic gas, and information about the motion of each object. That's where the spectroscopy comes in. By analysing the spectrum of the light, we can see how much it's been stretched as the source is pulled away from us by cosmic expansion. Connecting that measured expansion rate with an exact physical distance can give us invaluable information about the evolution of our cosmos (along with some really cool maps). DESI's newly released modelling made a splash by hinting that dark energy might have a more complicated history than we normally assume. If these hints hold up, they could reshape our understanding not only of the Universe's history, but also of our ultimate cosmic fate.

DR KATIE MACK

(@AstroKatie)

Katie is a theoretical astrophysicist. She currently holds the position of Hawking Chair in Cosmology and Science Communication at the Perimeter Institute for Theoretical Physics.

> **"It has evaded every attempt we've made to image or capture it"**

The concordance model of cosmology encapsulates our current best-guess working model of the Universe and its constituents. In this model, dark energy is a cosmological constant: an inherent property of spacetime, uniform and unchanging, that essentially just builds a little stretchiness into every bit of space. With dark energy as a cosmological constant, the observed density of dark energy would always remain the same over time. Unlike matter that dilutes when the space it's in gets bigger through cosmic expansion, more space just means more cosmological constant contained in that space. If dark energy were something *dynamical*, meaning its density or behaviour were changing over time, that change would show up in detailed measurements of the expansion history.

DESI and other surveys tend to report their dark energy results in terms of the so-called 'equation of state' parameter, written as w. If dark energy is a cosmological constant, we expect to see $w = -1$, exactly, for all time. If w is anything other than -1, or if it seems to be increasing or decreasing, dark energy must be something else.

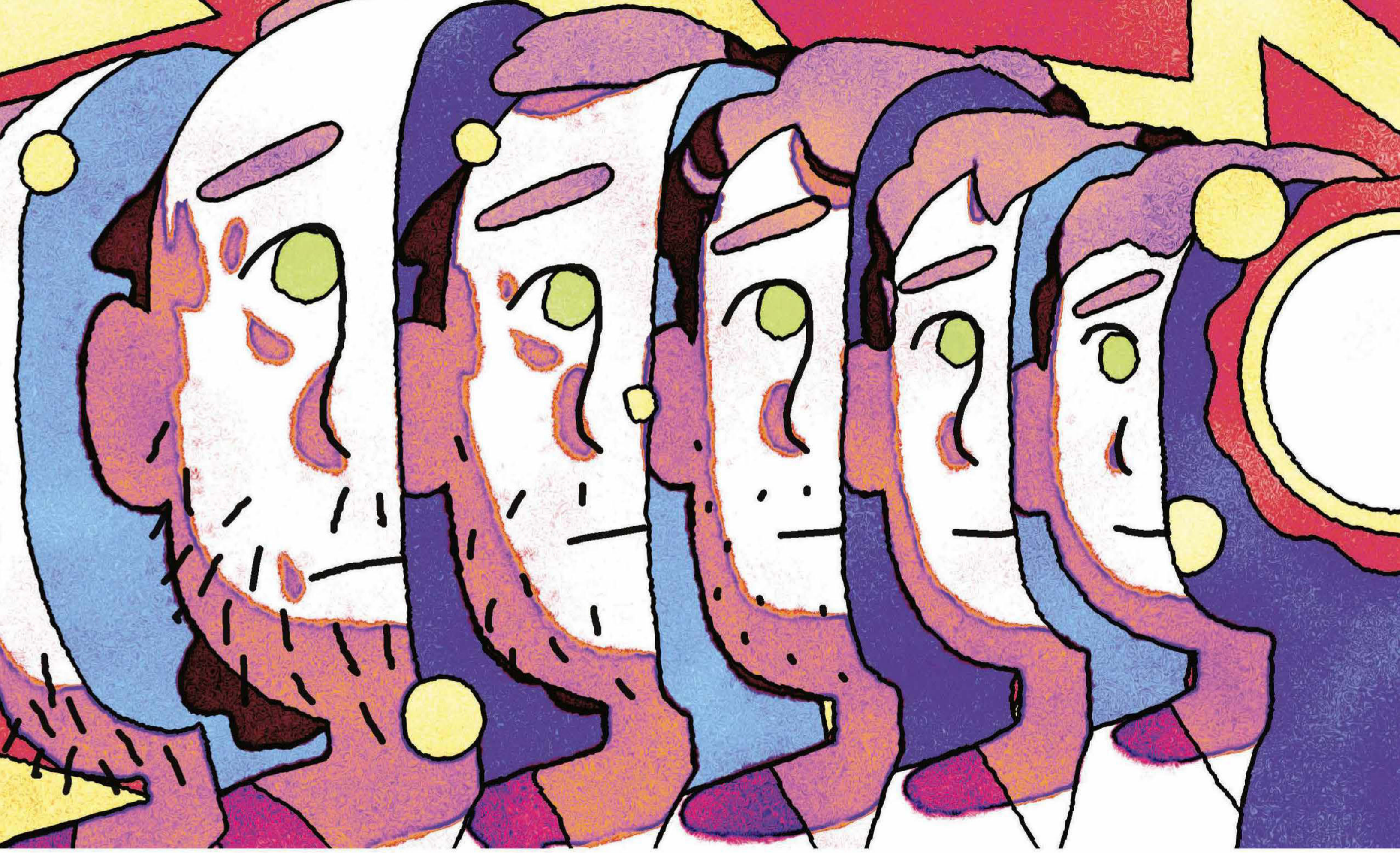
DESI's results provide an intriguing conundrum. When w is assumed to be constant, a value of -1 fits the results just fine. But when the analysis is altered to allow for the possibility that w has been changing, DESI's new results look different. Combined with other datasets from supernova surveys, they seem to suggest that a varying w, one that was lower in the past and will be higher in the future, matches the data best.

What this would mean for our cosmos is unclear. For a constant w, anything less than -1 is called 'phantom dark energy', and its ominous name is earned: it implies a distant future in which dark energy could literally rip apart galaxies, solar systems, stars and even the Universe itself. Phantom dark energy is disliked by theorists because it seems to break some really important fundamental principles that we think probably hold in the cosmos. While the new results suggest a movement *away* from the phantom regime, they seem to be implying that those principles could have been broken sometime in the cosmic past, which would give a lot of theorists headaches.

If w really is increasing, that might suggest that dark energy is getting less important over time. That could change our cosmic future in subtle but interesting ways, possibly leading to one in which the expansion of the Universe is no longer accelerating (though probably not allowing the expansion to reverse or stop entirely). The results from DESI are still just hints, which might disappear in future studies. Still, it's possible that dark energy has just found a new way to surprise us.

ILLUSTRATION: MATTHEW HOLLAND

FUSION



COMMENT

YOUR BRAIN DOESN'T SUDDENLY MATURE ON YOUR 25TH BIRTHDAY

If your brain isn't fully developed until you're 25, why are we asking young people to make so many life-altering decisions?

You may have come across the notion that if you're under 25, your brain isn't fully developed yet. It's been widely reported as fact and supposes that people who haven't yet reached 25 years of age can't think things through or make rational decisions, and so are less responsible than older folk. This fact has formed the basis of official government advice, prison sentencing and more.

The only problem is it's not a fact. Never has been. No matter how many TikTokers insist otherwise. Why is it wrong? Well, for lots of reasons.

Despite its prevalence, there's no actual data set or specific study that can be invoked or pointed towards as the obvious source of the claim that 'the human brain stops developing at age 25.'

It could be a misunderstanding, stemming from brain scanning studies that looked at subjects up to the age of 25. But that's like saying sprinters can't run further than 100 metres after watching the 100m final at the Olympics. The limit is imposed by the context, not biology. Others argue that 25 is simply a pleasing-sounding number and the idea caught on purely as a result. Stranger myths have spread this way (I'm looking at you, 'we only use 10 per cent of our brains').

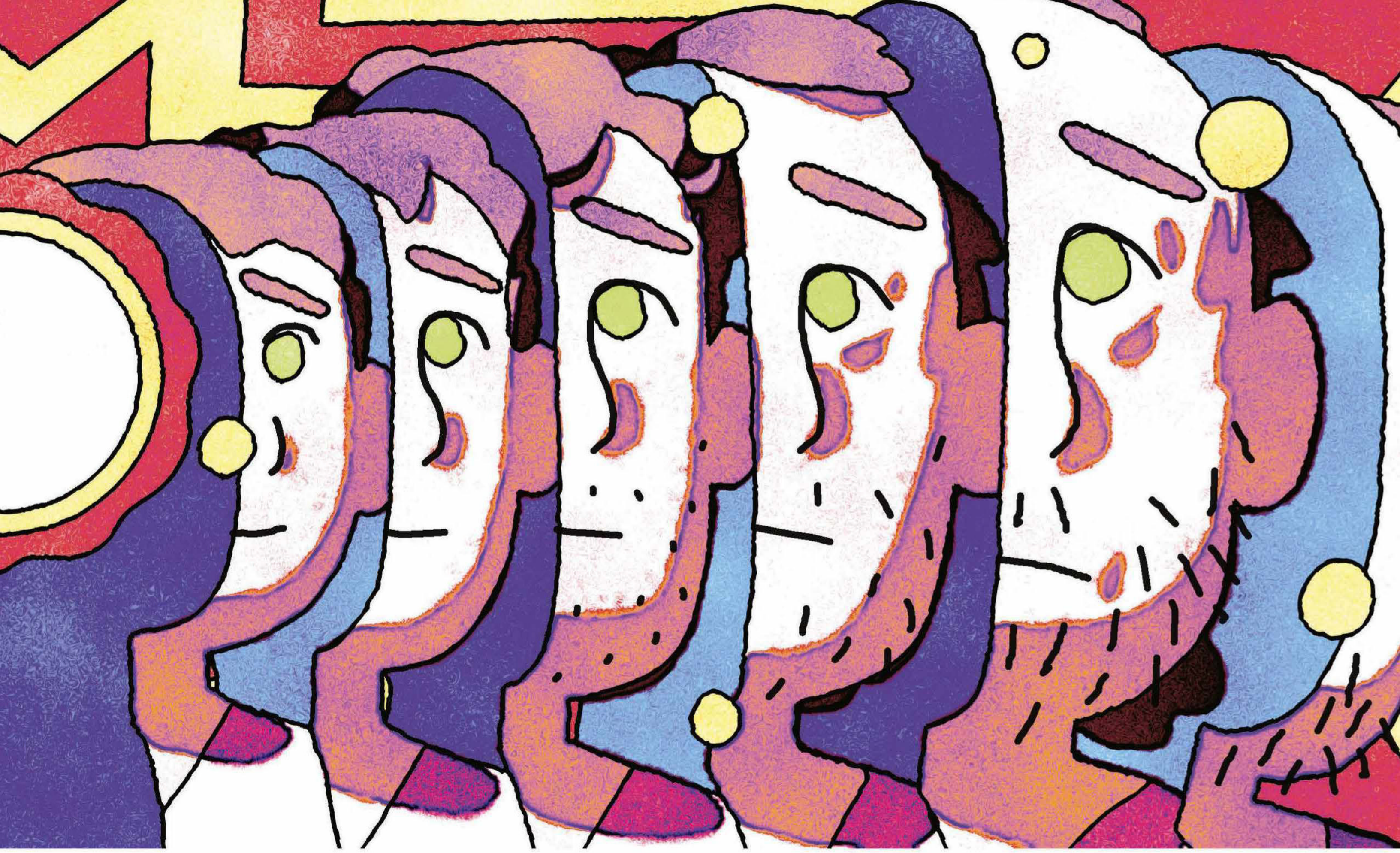
Just because age 25 isn't some firm endpoint for development, it doesn't mean the brain isn't developing before then. Because it is. In many cases, it's developing after that age too.

Exactly when 'developing' and 'maturation' ends is tricky to pin down. The human brain is essentially an assemblage of many different regions, of varying degrees of complexity, maturing at different rates.

But even if we focus on the frontal lobe, where all the reasoning and thinking occurs (mostly), it's still important to remember that brain development isn't like building a house. You don't have to wait until all the walls and floors are done, the plumbing is sorted out and the electrics are installed before you can actually live in it.

Brain development is more like evolution. There were many evolutionary species between the primitive rodent-like creatures that were the first mammals and modern-day humans. But each of these stages was, at that point, a fully functional, successful species. There were no unworkable intermediary

ILLUSTRATION: KYLE SMART



species, like a rat's torso on a pair of massive bipedal legs.

And it's the same with the human brain. Even if you believe that people under the age of 25 aren't 'as good' at decision-making as older people, it doesn't mean they can't do it, or shouldn't be allowed to. Think of it another way: I, for example, have nothing like the strength of renowned World's Strongest Man competitor Eddie 'The Beast' Hall. But that in no way disqualifies me from bringing the heavy shopping in from the car.

Even if it's entirely well-intended, basing official legislation or government policy on the premise that the human brain isn't sufficiently developed before the age of 25 sets a significant precedent. If 25 is seen as the legal minimum where you can be trusted to think things through and make decisions, then that would logically apply to all facets of life.

"It's important to remember that brain development isn't like building a house"

For instance, countless people choose and complete their degrees, and even PhDs, long before their mid-twenties. Also, the UK is the only country in Europe that allows recruitment in the military of people under 18 (and they must serve until they're 22).

Football academies can accept players as young as nine. And 25 is closer to retirement age for a professional player, as it is in many other sports.

These are just three examples of people being trusted to make massive, life-affecting decisions long before their brains are apparently 'fully developed'. And if we start insisting that anyone under 25 is too underdeveloped to do this, that has serious ramifications.

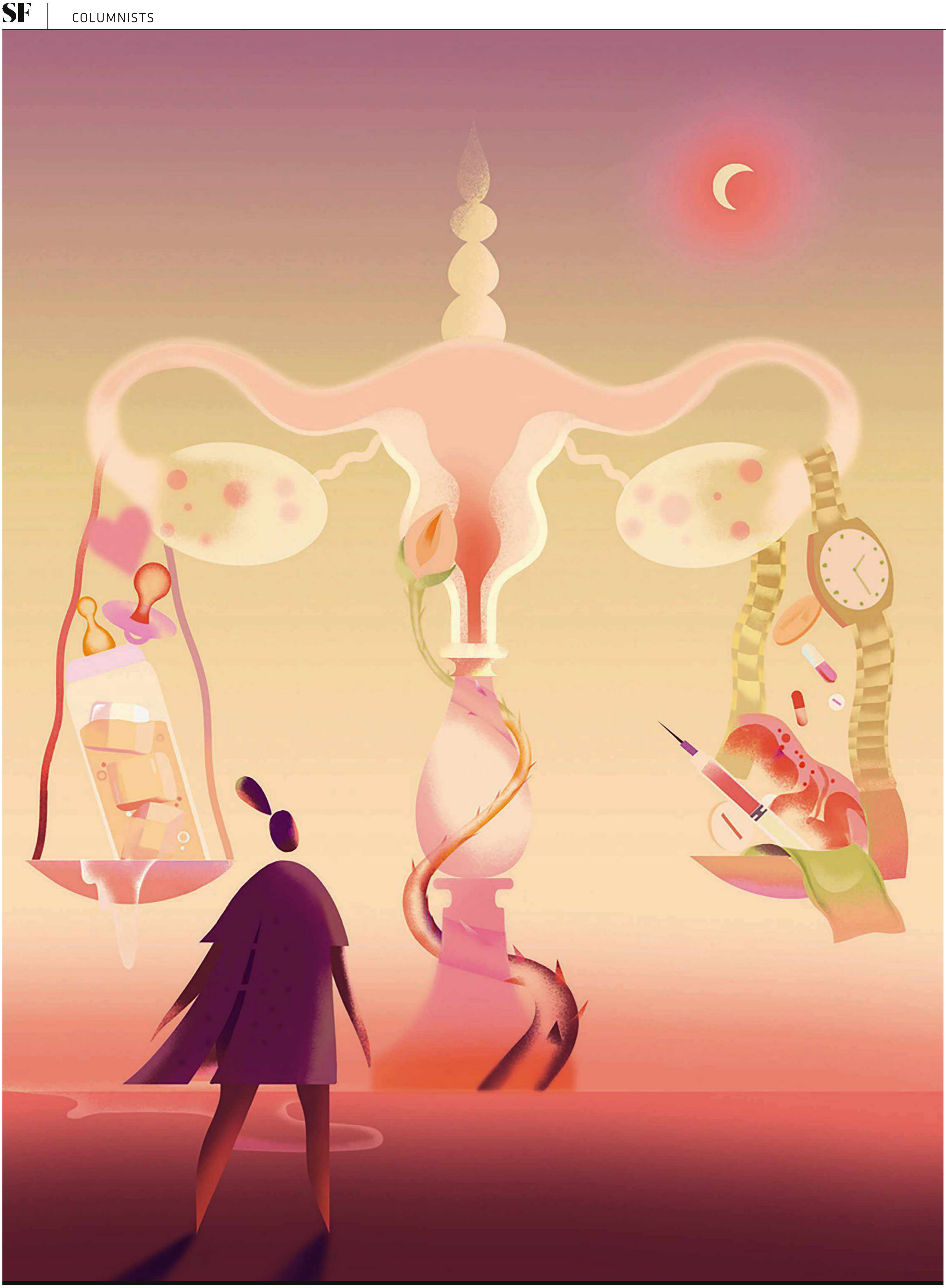
Let's take it further. Suppose the argument is that your reasoning abilities must function at maximum before you can decide anything important. In that case, we need a maximum age too, not just a minimum.

Development is one thing, but there's also cognitive decline – age and entropy can't be avoided. That's why people show reduced mental abilities from middle age onwards. Some studies suggest our cognition truly starts to decline in our twenties, however. This would suggest there's maybe a window of a few months when we can be 'trusted' to make decisions.

Of course, this is a wildly reductionist, overly simplistic perspective. But the same can be said about the whole 'under 25' idea. Even if it were true. Which it mostly isn't. And you don't need to be a certain age to grasp that.

DR DEAN BURNETT

Dean is a neuroscientist and author. His latest book, Emotional Ignorance *is out now in paperback (£9.99, Guardian Faber).*



COMMENT

COOL HEADS ARE NEEDED WHEN CONSIDERING EGG FREEZING

Egg freezing is helping more women to start and grow their families. But it isn't a simple solution

Should I consider egg freezing if I want a family in the future? It's a question that you, or somebody close to you, may have asked recently. With more and more women looking to preserve their fertility as they age, egg freezing has become the fastest-growing fertility treatment in the UK. There were 11 times more egg freezing cycles in 2021 than in 2011.

Many women opting for the treatment may seem young – under the age of 30 – but the ovaries age far quicker than the rest of our organs. Why, exactly, isn't clear, but the consequences of it are well understood: as ovaries age, there is a progressive loss of eggs that ultimately leads to menopause and infertility.

In addition to the number of eggs decreasing, the 'quality' of the eggs reduces as the ovaries age. Over time, there are more changes in the DNA, the genetic material, in the eggs. This leads to an increased rate of chromosomal abnormalities, resulting in an increased rate of miscarriages, pregnancy complications and babies born with genetic conditions. Therefore, egg freezing (also known as oocyte cryopreservation) is seen as a promising option by many. But how does it work? How reliable is it? And what are the risks?

> "Key considerations include the risk to women regarding hyperstimulation of the ovaries"

Egg freezing is a medical process that involves hormonal stimulation of the ovaries to overproduce eggs. These eggs are then retrieved during a procedure in which a healthcare professional accesses the ovaries by passing a needle through the vagina and out into the pelvis under ultrasound guidance. Most women aged 38 years or younger will have around seven to 14 eggs harvested, but those with a lower ovarian reserve will produce fewer eggs for collection.

Eggs are then collected from the ovaries and the viable ones are frozen and stored until needed. When a woman wants to proceed to the next stage, the egg is fertilised in a lab via in vitro fertilisation (IVF). Then one, or multiple, viable embryos are implanted back into the woman's womb to further develop – hopefully to a full pregnancy.

There is much research and development, and testing and trialling, of different methods in multiple parts of the process to deliver the best results.

For example, the egg-freezing process can be slow or fast – the latter is known as flash freezing or vitrification. Flash freezing has been shown to increase egg survival and improve pregnancy rates. It aims to first fortify the eggs with a cryoprotectant, then cool them 'ultra-rapidly' in an effort to solidify the cell and avoid the formation of ice crystals.

With assisted reproductive technologies, nothing is guaranteed and egg freezing is no different. Using data from women mainly under 30, it's estimated that the survival of eggs after vitrification and thawing is 90–97 per cent, the fertilisation rate is 71–79 per cent and the implantation rate is 17–41 per cent. The overall pregnancy rate per vitrified and thawed oocyte is as low as 4.5–12 per cent.

It should also be noted that egg freezing and consequent IVF do present challenges. Some key considerations include the risk to women regarding hyperstimulation of the ovaries and carrying a pregnancy at an older age. There's also risk to the offspring, such as reported lower birthweight, intrauterine growth restriction and a possible increased risk of congenital abnormalities.

One of the highest medical risks can be caused by the hormone medication-induced hyperstimulation of the ovaries. This can lead to ovarian hyperstimulation syndrome, bringing about a shift in fluid from blood vessels out into the 'third space' in the body, where fluid shouldn't normally accumulate.

The syndrome can be life-threatening in approximately 0.1–3 per cent of patients who experience the severe form, causing blood clots, shortness of breath, abdominal pain, dehydration and vomiting that necessitates hospital admission. There is also the more common mild-to-moderate form of the syndrome involving fatigue, nausea, headaches and abdominal pain. All women undergoing ovarian hyperstimulation need to be closely monitored for the syndrome.

These are the biggest risks related to egg freezing, but there are also big questions related to the treatment that likewise deserve our attention. For instance, is it right to emphasise genetically related children as the only way to grow a family? Does egg freezing put further reproductive responsibility on women?

While answers to these questions may differ from person-to-person, we can all agree that egg freezing is a technological feat that's enabled many women to become pregnant in situations when previously it would have been impossible. And now the science is here, we need to properly evaluate the potential risks and consequences.

DR MICHELLE GRIFFIN

Michelle is the director of MFG Health Consulting, as well as a women's health expert and strategy advisor in women's health tech.

ILLUSTRATION: OLGA ALEKSANDROVA

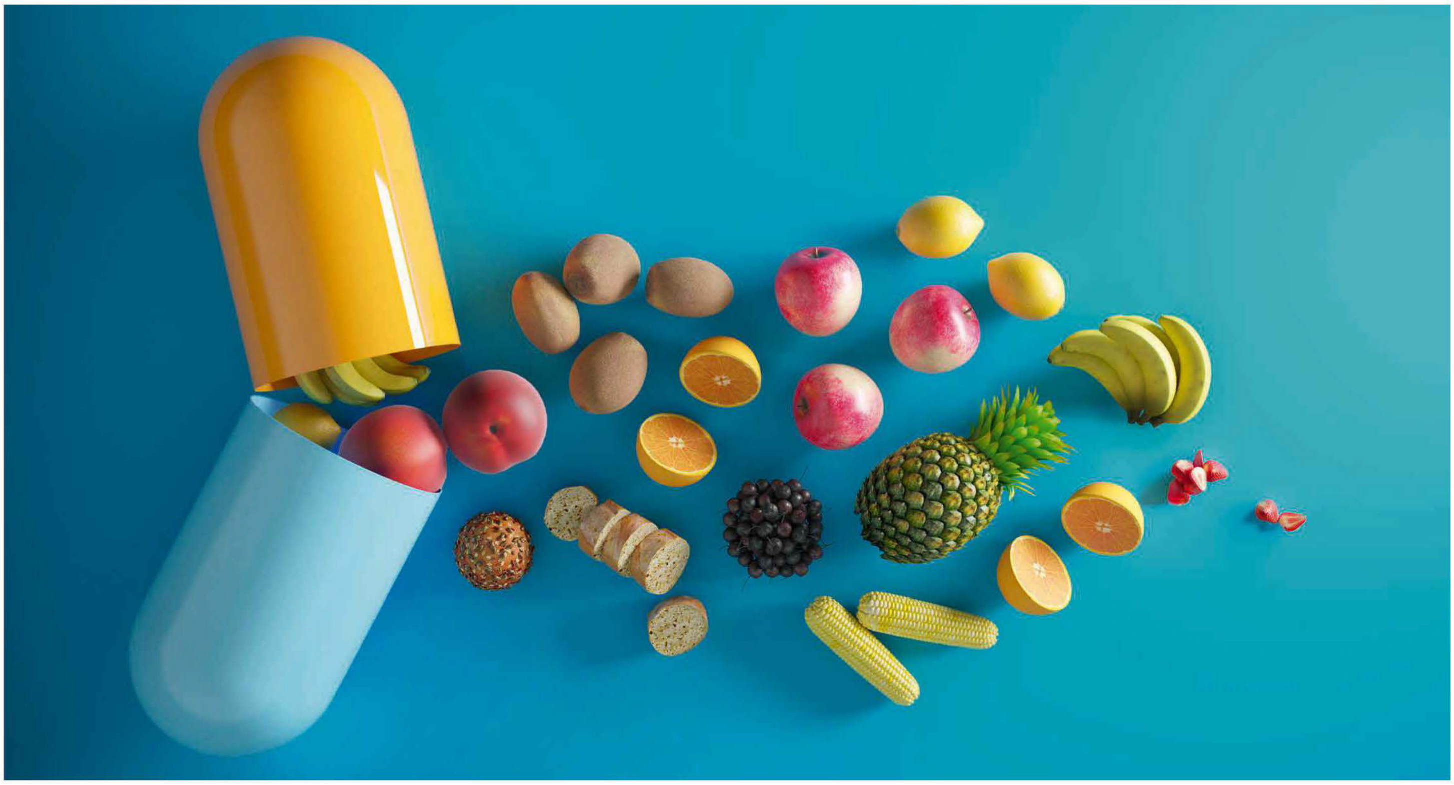
REALITY CHECK

THE SCIENCE BEHIND THE HEADLINES

REVIEW

Food for thought: your diet is vital for a better brain

Nutritional deficiencies are causing widespread neurological issues. But food is one way to fight them



ABOVE A diet containing sufficient amounts of nutrients and fibre has health benefits for your body and brain

Neurological conditions are the leading cause of illness and disability around the world. According to the World Health Organization, they affect more than three billion people.

The state of our collective brain health has even been described as an 'emergency' by the Federation of European Neuroscience Societies. And it's easy to see why: declining neurological health on this level is a new threat, on both a micro and macro level. Poor brain and mental health is linked to lower lifetime earnings for people and the social care costs of dementia in the UK now outstrip those for cancer, stroke and heart disease combined.

This all means finding ways to protect neurological wellbeing should be a public health priority. And recent research suggests that nutrition could be a valuable tool.

In one study, researchers took data on food preferences from 181,990 anonymised people in the UK Biobank and divided them into four dietary subgroups: starch-free or reduced starch; vegetarian; high protein and low fibre; and balanced. The data was then analysed against a range of other factors including mental health, cognitive functions, and blood and metabolism biomarkers. The researchers found that diet can determine brain structure, which influences mental health and cognition.

So, what should we be eating to keep our brains healthy? Here are three science-backed suggestions…

GET THE RIGHT MICRONUTRIENTS

Nutrients are essential for brain development so deficiencies are an issue. For example, iodine deficiency is the leading cause of preventable brain damage worldwide and during pregnancy can lead to permanently suppressed offspring IQ (67 per cent of pregnant women are iodine deficient). The NHS advises adults to have 140 micrograms of iodine daily. Seaweed, dairy products and fish are rich sources.

Similarly, cobalamin (vitamin B12) is so vital for normal neurological function that deficiency causes a range of psychological and cognitive impairments, including confusion, impaired judgement, anxiety, depression, forgetfulness and dementia. The NHS currently recommends adults have 1.5 micrograms a day of vitamin B12 and it can be found in meat, fish, eggs and cheese (vegetarians often take a supplement, often in tablet form).

> “67 per cent of us are not hitting our five-a-day target for fruit and veg”

Polyphenols (found in berries, tea, coffee and legumes) and omega-3 fats (from oily fish) help generate new neurons. They also promote the growth of new connections in the adult brain and protect ageing brain cells.

INCREASE YOUR FIBRE INTAKE

Low fibre intake contributes to pro-inflammatory changes in the gut microbiome and the degrading of the protective gut lining, as fibre-starved microbes go in search of something else to eat. If gut bacteria get into the bloodstream, the immune system identifies them as pathogens, which triggers an inflammatory response. This inflammation can provoke neuroinflammation, a recognised feature of major depression, schizophrenia and Alzheimer’s disease.

When they get the fibre they need, gut microbes break it down to produce a range of by-products including vitamins and neurotransmitters. One class of by-products are short-chain fatty acids, which not only feed the cells that line the gut, helping to support the integrity of the gut barrier, but can do the same for the blood-brain barrier (BBB) too.

The BBB is a highly selective structure that prevents toxic proteins and other pathogens from entering the brain. We know that impaired BBB integrity is an early precursor to neurodegenerative conditions such as Alzheimer’s disease, raising the possibility that diets low in fibre could be contributing to neurological illness.

Currently, not a single age group in the UK is meeting the recommendations for fibre intake, which for adults is 30g a day according to the NHS. Oats, legumes (such as beans and lentils), fruit and vegetables are all great sources of fibre.

AVOID FAD DIETS

Another concern is the online promotion of extreme dietary practices, such as the carnivore diet, which encourages people to eat only animal products (meat, eggs and dairy) and to exclude fibre-rich plant foods.

Such diets are endorsed as a fast track to fat loss and muscle growth and have, consequently, become popular with young men. But, while they might encourage young people to eat fewer ultra-processed foods, they could be introducing immunological changes that put young brains at increased risk, at what is already a vulnerable time for mental health.

What’s clear is that, as a nation, we’re not eating enough of the foods known to support brain health and development. Twenty years after the campaign was introduced, 67 per cent of us are not hitting our five-a-day target for fruit and veg. Close to 60 per cent of our diets are ultra-processed, and there’s an inverse relationship between the proportion of ultra-processed foods in the diet and nutrient status.

These stats alone should give us pause. The brain is an extraordinarily hard-working organ with a high demand for energy and a broad range of nutrients – nutrients that most of us aren’t getting enough of.

BBC

For more fact-checking news, visit the BBC’s Verify website at ***bit.ly/BBCVerify***

ABOVE Fibre, in oats, and polyphenols, in berries, both have beneficial effects for your brain function

GETTY IMAGES X2

by **KIMBERLEY WILSON**

Kimberley is a chartered psychologist and visiting lecturer working in a private practice in central London.

ANALYSIS

'Rogue waves' capable of sinking ships are raging across our oceans... and scientists don't know why

There are calls for greater monitoring to help build prediction models for these deadly waves

For hundreds of years, seafaring folk have told of 'rogue' or 'freak' waves coming out of nowhere and threatening their vessels. It wouldn't be until New Year's Day 1995, however, when a 26m-high (85ft) surge was recorded at a gas platform in the North Sea, that scientists started taking such reports seriously.

The extreme and unpredictable activity has been blamed for numerous incidents at sea. In 2018, eight crew members had to be rescued when waves sank their fishing boat off the Hawaii coast. More recently, a rogue wave slammed into a cruise ship in the Antarctic Ocean, shattering windows and injuring several passengers, one of them fatally. Yet it remains unclear how common rogue waves are.

One study based on media reports recorded just 210 waves worldwide between 2011 and 2018, but the real number is thought to be much higher.

It's worth noting that rogue waves differ from tsunamis. The latter are large waves (or a series of waves) that crash onto a coastline, usually following an earthquake or volcanic eruption under the water. While the waves caused by a tsunami can be tall, they're also long in profile. Rogue waves, by contrast, have much steeper slopes and don't break just on shorelines; they can break in open ocean. Technically, they're defined as being at least twice the height of the surrounding waves, although this definition can be misleading, according to University of South Florida researcher Laura Azevedo.

"It's a bit of a problem because you can have a rogue wave that's 1m (3ft) high and that won't do anything to anybody," she says. Azevedo favours a threshold of 4m (13ft), which she says is the height at which a wave starts to become dangerous.

Exactly what triggers rogue waves is up for debate. What is known is that they're not related to movement on the seabed. It's thought that there are several other factors at play.

A team at the University of Oxford, led by engineer Dr Tianning Tang, is attempting to understand their root causes by combining computer modelling with

ABOVE Rogue waves that break in open ocean can threaten even the largest vessels, like cruisers or tankers

“Although depth changes do generate bigger waves, the effect is suppressed when the waves are spreading, rather than all heading in the same direction”

lab-based experiments in large tanks that use paddles to generate waves.

Particularly, the team has explored the influence of sudden depth changes. “This is a very important problem around continental shelves, for example, where the waves propagate from the deep ocean to coastal areas,” says Tang. It also affects the banks created to house offshore wind turbines.

The results show that although depth changes do generate bigger waves, the effect is suppressed when the waves are spreading, rather than all heading in the same direction. According to Tang, this means sharp drop-offs are less concerning in the ocean than in the lab, since real waves tend to spread.

This chimes with what Azevedo found during her own studies of ocean waves at Tampa Bay, Florida. Thanks to a monitoring buoy, she was able to get four years’ worth of high-quality data on wave heights at the entrance to the bay, identifying 7,593 waves (more than 10 per cent of the total) meeting the technical definition of rogue waves. Among them, 372 waves were over 4m (13ft).

BELOW One of the monitoring buoys that collects data on waves entering Tampa Bay, Florida

TB-PORTS
WAVE BUOY
866-TB-PORTS

GETTY IMAGES, UNIVERSITY OF SOUTH FLORIDA COLLEGE OF MARINE SCIENCE

Azevedo says she “couldn’t find one specific reason” why they occurred, but they were more common when waves were travelling in one direction as opposed to spreading out. “It’s understandable,” she says. “When you have all the energy of the sea creating that one wave, that’s a big wave.”

Her work also highlights how at Tampa Bay, which is sheltered by land to the east, the most dangerous waves come from the west and more often when conditions are stormy or windy. The causes of rogue waves are not universal, however, so Azevedo’s results may only be relevant for bays comparable to Tampa’s.

All this makes it difficult to predict when rogue waves will strike, at the moment. As understanding grows, scientists could use modelling techniques to make more accurate long-term predictions. This might, for example, allow the owner of an offshore wind turbine to know how many waves over 4m (13ft) they could expect during the next 20 years.

But, as Tang notes, it’s much harder to make short-term predictions that tell crew members whether a rogue wave is going to hit their ship in the next, say, 20 minutes.

That said, in 2016, researchers at Massachusetts Institute of Technology (MIT) did claim to have developed a prediction tool capable of spotting waves that could become a problem within two to three minutes. Improved monitoring could boost efforts to predict rogue waves.

Right now, Azevedo says, most monitoring buoys don’t transmit maximum wave heights, but send ‘significant wave height’, which is an average of the tallest 33 per cent of waves over a given period. “So you’re missing the big waves,” she says, adding that this would be simple to change.

Better data could account for extreme waves – which, by some estimates, are already increasing due to climate change. Azevedo suggests one solution could be for designers to make ships resilient enough to withstand double the significant wave height. That would no doubt need some convincing, due to the increased costs.

by HAYLEY BENNETT

Hayley is a science writer based in Bristol, UK.

COMMENT

Your snoring may be a sign of more serious health issues

When it comes to snoring, noise might be the least of your worries

Almost all of us snore, just in different ways. Some of our bedrooms are accompanied by the soundtrack of a gentle rhythmic hum, while others are filled with a loud rumble. For most, snoring can be considered entirely normal (if a little irksome for their partners), but for some people, it's a sign that not all is well. It may be an indication of sleep apnoea.

Sleep apnoea is a condition characterised by stops and starts in one's breath during sleep. Rarely, this may be due to the brain not signalling for us to breathe, something known as central sleep apnoea. The far more common type, however, is obstructive sleep apnoea (OSA). This occurs when there's a mechanical obstruction in the airway that prevents air from entering the lungs when we inhale while asleep.

OSA is common, affecting about 13 per cent of men and six per cent of women. While more prevalent in older people, it can affect children too.

So how does it arise? The upper airway linking the mouth to the windpipe is essentially a floppy tube, held open in part by many small muscles. As we drift off to sleep, these muscles lose tension, increasing the tendency of the airway to collapse when we inhale. Anything that makes our airway narrower can increase the risk of it being blocked, such as having large tonsils or a small lower jaw. Sleeping on our backs and with our mouths open also has an impact.

Men are more likely to have OSA, with the risk being two or three times higher than for women, which is most likely due to hormonal effects on breathing control. But the single strongest factor is obesity, as fat deposits gather in and around the airway.

Each time the airway becomes obstructed, we partially awaken (something that we may or may not be aware of), until breathing returns to normal. This can lead to disruption of sleep several times a night, but in extreme cases, it can occur more than a hundred times an hour.

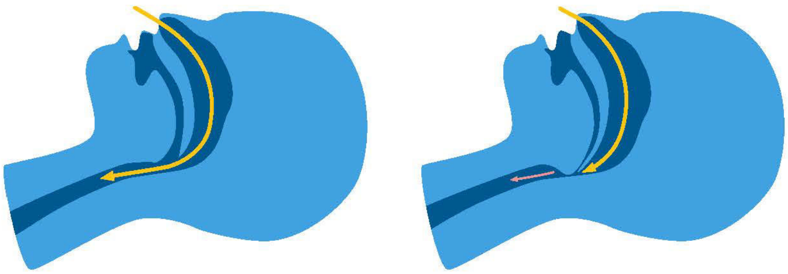
Unsurprisingly, people with OSA can struggle with sleepiness during the day as a result of poor and broken sleep, and they'll occasionally experience a sensation of choking or gasping overnight. The reverberation of the soft tissues at the back of the throat can cause inflammation or irritation too, resulting in people waking up with a dry mouth or sore throat.

There are other effects of OSA that are less obvious. Due to hormonal changes related to the airway obstructions and sleep disruption, people with OSA may need to get up frequently at night to pee and they may gain weight due to increased appetite. Occasionally, it'll even make a person feel like they're not sleeping, which can be mistaken for insomnia.

As a result of effects like the recurrent drops in oxygen in the bloodstream, the changes to the nervous system and increased inflammation, OSA can be bad for your health in a number of ways. It can lead to a range of conditions, such as high blood pressure, type 2 diabetes, cardiovascular disease and stroke.

RIGHT This device treats obstructive sleep apnoea by generating positive air pressure that prevents the airway from collapsing

OBSTRUCTIVE SLEEP APNOEA: INSIDE THE AIRWAY



NORMAL AIRWAY

AIRWAY WITH OSA

> "Each time the airway becomes obstructed, we partially awaken… In extreme cases it can occur more than a 100 times an hour"

GETTY IMAGES

OSA has also been associated with various aspects of brain health, including cognitive abnormalities, mood and anxiety levels, and even dementia.

The jury is out on whether OSA directly causes these problems, however; while evidence grows that OSA contributes to these conditions, definitive proof that treating it reduces risk remains scant.

When it comes to treatment, a major obstacle is recognising that you have OSA in the first place. The symptoms often creep up on people and can go unnoticed for many years. Until recently, there has been a lack of knowledge about the condition and a scarcity of clinical services in the UK. For these reasons, it's estimated that about 80 per cent of people with OSA in the UK are undiagnosed.

There are, however, several treatment options. Weight loss can help and even cure it entirely. If a person's sleep apnoea only occurs when sleeping on their back, a range of devices known as positional sleep trainers can be used to promote sleeping on the side.

Dental retainers, called mandibular advancement devices, are designed to hold the lower jaw in place and push it forward a little – so expanding the airway – which can also provide relief.

For those suffering from more severe OSA, the best treatment is called automated positive airway pressure (APAP). This involves wearing a mask strapped to the face covering the nose, mouth or both, and then attached to a small machine that generates positive air pressure. This essentially prevents the airway from collapsing.

Given that the sensation is a little like breathing into a strong wind, APAP isn't tolerable to everyone, but it can transform the sleep of people with OSA and change their lives. In just the last year or two, some people have had a medical device similar to a pacemaker surgically inserted, which stimulates the muscles of the tongue and throat in sleep and thus keeps the airway open.

It's important to remember that anyone can have OSA: any age, any gender, any weight. If you're snoring, waking with a sensation of choking or gasping, or have been noted to stop breathing in your sleep, your first port of call should be your doctor.

They can provide you with a simple home-based test to monitor your oxygen levels and breathing patterns and so determine the treatment. This could make all the difference between feeling like a train wreck throughout the day or waking up fresh as a daisy. There's no need to suffer in (relative) silence. **SF**

by **GUY LESCHZINER**

Guy is a consultant neurologist and service lead for sleep disorders at Guy's and St Thomas' hospitals, London.

INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

INNOVATIONS

A PROTEIN MADE FROM AIR COULD BE THE NEXT BIG FOOD TREND

Solein, a protein made from air, is gaining traction for its small carbon footprint. Will it become the go-to food source for all of us?

There's a change occurring in the way we get our food. Steadily, farms are being switched for labs; fields of crops with vertical walls of produce; and meats with cultured cells. And now, a protein made from air.

Solein was developed by Solar Foods to be a safe, environmentally friendly and delicious way to get protein into our diets. Launched in 2021, Solar Foods is now upping the ante by unveiling its first factory in Vantaa, Finland.

PULLING PROTEIN FROM THIN AIR

So how do you turn air into food? "It's a gas fermentation process, similar to beer," says Ying Zhang, a molecular microbiologist and assistant professor at the University of Nottingham. "Where beer uses sugar, wheat and starch to convert the sugar material into alcohol, this is using gas as a feed, which includes carbon dioxide – hence the term 'air protein'."

Solein uses a special type of microbe that grows by feeding on air (carbon dioxide) and hydrogen. Fed a broth of nitrogen, minerals and other nutrients, the microbes multiply and can be separated from the liquid through centrifugation (spinning molecules really fast). What is left is dried into a fine powder that's roughly 60–70 per cent protein. This can be turned into flakes or chunks to mimic the shape of meats.

Not only high in protein, Solein is free of gluten, dairy and soy. It's vegan, lacking in known allergens and, based on Solar Foods' claims, contains all the nine essential amino acids, carbohydrates, fats and minerals found in other foods. And it's versatile, used already to make, among other things, pasta, gelato and snack bars.

"SOLAR FOODS CLAIMS THAT SOLEIN PRODUCTION IS 100 TIMES MORE CLIMATE-FRIENDLY THAN MEAT"

Solein's big selling point is its carbon footprint. It needs nowhere near the same amount of water for land irrigation, or as much electricity as some factories. Solar Foods claims Solein production is about 10 times more climate-friendly than most plant-based proteins and 100 times more climate-friendly than meat.

FOOD OF THE FUTURE

So it's a miracle food, right? Well, there are drawbacks. Firstly, Solein is still awaiting approval. So far, it has gained novel food regulatory approval in Singapore only, allowing for the import, manufacturing and sale of foods containing Solein. Solar Foods has applied in the EU, UK and US, but their air protein can't become a global force without further approval.

The second issue is hydrogen. The fermentation process relies heavily on it – and hydrogen has a habit of going boom. Pasi Vainikka, CEO of Solar Foods explained to *BBC Science Focus* that they are serious about hydrogen management, using the right materials in the tubing and tanks, as well as appropriate materials for the conditions of explosive gases. "It's our team's responsibility, as well as a key skill and a strategic asset."

Hydrogen can be an environmentally friendly method of fuel, but it depends on how it's produced. In the case of Solar Foods, the preferred way is with electrolysers, a device that electrocutes water to split it into hydrogen and oxygen.

Finally, even if Solar Foods sets up a safe factory and gets widespread approval, there remains the concern found with any new product. While Solein contains the needed protein and other nutrients, it remains an unproven part of our diet.

There are certainly kinks to work out. But Solein looks promising. High in protein, kind to the environment and with an expected price of €6 per kg (about £5/$6.50), it could change the future of food – provided it passes regulation.

RETRO, REIMAGINED:

THE TECH BRINGING BACK THE GOOD OLD DAYS

We all love a bit of nostalgia. Things from the past feel cooler, more loveable. Happily, we're seeing old-school gaming, music and more return with a modern twist

Analogue Pocket
Analogue Pocket

...RETRO GAMING

Let's get real for a second. Handheld gaming has never quite managed to live up to the Game Boy era. Sure, there's been the Nintendo Switch, the Steam Deck and even the PSP, but nothing quite like the classic Game Boy. While all of these devices have given us some great memories, the nostalgia of playing *Pokémon*, *Super Mario* and *Metroid* on the Game Boy's simple, tiny, greyish-green screen feels particularly special. That's why the gaming company Analogue designed the Pocket – a sleek and modern tribute to the Game Boy. By slotting your old cartridges into this system, you can play over 2,780 Game Boy games, while enjoying some modern additions, including Bluetooth connection for headphones, a brighter display and louder speakers. The most modern feature of all? A highly inflated price tag. The Analogue Pocket sold out at rapid speeds and we're not surprised at all.

Analogue Pocket
$219.99 (approx £175), analogue.co

...RETRO MUSIC ON THE MOVE

we
are
rewind

The cassette players of yesteryear are fondly remembered. What's less remembered is the struggle to untangle the chewed-up ribbon and the sweat and tears of making a mixtape. Good thing those days are behind us, right? Well, the cassette is making a somewhat expected comeback and We Are Rewind has launched a player with a 2020s slant.

We Are Rewind cassette player
£129, wearerewind.com

...RETRO HOME MOVIES

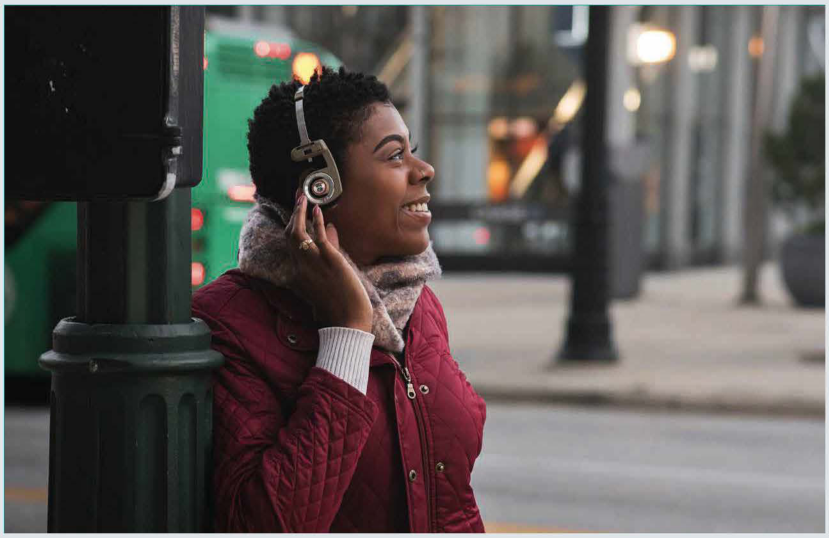
Endorsed by masters of the film world including Steven Spielberg and Christopher Nolan, the Kodak Super 8 remake is proving popular. It takes the form factor and concept of the original Super 8, and adds a few changes, including improved camera quality, to bring the technology into the 21st century. So popular, it's currently out of stock.

Kodak Super 8 Camera
$5,495 (approx £4,375), kodak.com

...RETRO HEADPHONES

From what's in the charts to fashion trends and even the latest gadgets to try, TikTok has a tight grip on what's considered cool these days. So what's cool to those looking for a new pair of headphones? That'll be the Koss Porta Pro. If these look familiar to you, it might be because they've been a staple of the headphone market since 1984. All this time later and they're still available to buy brand new, practically unchanged. That means you get a design that lives, breathes and emulates the 80s, without having to go second-hand. A simple metal headband and plastic earcups keep the design simple. The headphones lack modern features like Bluetooth or noise cancellation, but they're surprisingly capable in terms of audio (not all that unexpected, really, from headphones that have continued to be popular for 40 years). However, due to the capricious nature of trends, we're sure the internet will pass them by in the very near future.

Koss Porta Pro
£32.99, koss.com



...RETRO RADIO

No one makes being stuck in the past look as good as the audio company Roberts. Dating back to 1932, you'd be excused for not realising Roberts has innovated quite a bit since then. On the outside, this range of alarm clocks, speakers, radios and even turntables, could have easily come straight from the 1950s, complete with the stylings of the past. In reality, Roberts is riding the retro trend with style, blending old-school exteriors with modern interiors. That means built-in Spotify and Deezer, Bluetooth, smart radio and, of course, a boost in specs for the speakers. This blend of the old and new has garnered Roberts a loyal fanbase, with admirers using the devices to add some charm to their homes. Nearing a whopping £200 for the Revival iStream, though, nostalgia doesn't come cheap, considering the somewhat lacklustre list of features on offer from all of Roberts' many speakers and devices.

Roberts Revival iStream
£199.99, robertsradio.com

Ideas we like...

Our pick of the month's smartest tech

...A POWER BANK FOR PESSIMISTS

Anker has come a long way. Once a company of small power banks, it's now selling what is essentially a massive energy storage system for doomsday preppers. The Anker Solix X1 stores energy built up during the day from solar panels to use at night, optimising power usage to reduce bills. That's nothing new, plenty of companies can do that. What's special here is the resilience. The Solix can withstand extreme weather, cold and heat and responds rapidly when there's a power outage, kicking in to replace power from the grid.

Anker Solix X1
£TBC, anker.com

6.0kW
100%
6.0kW
ANKER
SOLIX

↓...A MORE AFFORDABLE RUNNING WATCH

As running clubs become the forum for social gatherings and marathons the go-to bucket list item, 2024 seems to be turning into the year of the run. To that end, Garmin, the maker of high-tech sports watches, has introduced a model for beginners: the Forerunner 165. Despite its £250 price tag, it's something of a budget watch by Garmin's usual standards, but it's smart enough to track all the metrics newbies might need. It can set up workouts, track your recovery time, sleep and heart rate, and, of course, the speed and distance of your runs.

Garmin Forerunner 165
From £249.99, garmin.com

Beats
Yesterday
2:00
GARMIN
Today's Suggestion
Tempo
3x8:00@160 bpm
50:00
GARMIN

↓...A PAIR OF EARBUDS TO HELP YOU SLEEP

They say you fall asleep faster next to someone you love, but when that person snores, this theory quickly falls apart. Thankfully, there are a range of earbuds that can help you sleep in noisy surroundings. The Soundcore A20 buds are designed to be worn all night, fitting neatly in your ear to avoid discomfort. This snug fit aids the noise cancellation as well, blocking out most loud and disruptive noises and adjusting how much sound is allowed in, depending on how loud it is. Can't get settled? These buds also come with a whole library of relaxing sounds to drop off.

Anker Soundcore A20
$149 (approx £119), UK.soundcore.com

↓...A CHATGPT-POWERED PAIR OF EARBUDS

Yes, we're sick of hearing about ChatGPT too, but trust us… this is quite cool. Tech company Nothing has unveiled their new Ear (a) earbuds. They have all the usual features – active noise cancellation, long battery life and an array of microphones to make your voice clear even on windy days. But they also have ChatGPT built in. Why? So that you can ask the generative AI questions on the go. When a burning question pops into your head, just squeeze the headphones and ask it. Then you'll get an answer (of sorts). It helps that they look cool, too.

Nothing Ear (a)
£99, nothing.tech

↓...AN EXTREMELY BRIGHT TV

On the face of it, the Sony Bravia 9 doesn't look or sound like anything interesting, but in actual fact, it's a set that might just revolutionise the television industry. The best TVs on the market tend to use OLED displays. These are the highest quality screens, or were until now, at least. With the Bravia 9, Sony has used Mini LEDs to vastly improve the brightness of its display compared to leading competitors. Better still, it manages to do this while reducing the energy consumption of the TV while still maintaining an incredibly high quality for your viewing pleasure.

Sony Bravia 9
From £4,499, sony.co.uk

IDEAS WE DON'T LIKE...

...THE DUMB PHONE GETS DUMBER

HMD (formerly Nokia) has just released a boring phone. That's not us being critical; it's the company's own words. The idea, dreamed up with the help of Heineken, is a phone that does less in order to help you socialise more, by getting your eyes off social media and focusing on your friends. You can only get one by winning a competition, so it feels more like a thinly veiled advert to go to the pub, rather than anything with genuine good intentions. Promotions for the phone boast about its ability to let you text your friends, take selfies and… add swagger to it with stickers.

Boring Phone
£0, HMD.com

...AN OVERPRICED CD PLAYER

Do you remember CDs? Those little discs that played music? Well, following in the footsteps of their older brother vinyl, CDs might be making a comeback, thanks to Bang & Olufsen's new Beosystem 9000C. The company has recreated its iconic CD player from the 1990s and given it an update. But this version is outrageously expensive (at a whopping £45,000) and exclusive (with only 200 available). The price does include two Beolab 28 speakers, though, which cost £14,500 alone.

B&O Beosystem 9000C
£45,000, bang-olufsen.com

SFP406

BBC
Science Focus MAGAZINE
SUBSCRIPTION ORDER FORM

Please complete the order form and send it to:
FREEPOST OUR MEDIA (please write in capitals)

UK DIRECT DEBIT

☐ **Yes, I would like to subscribe to/renew *BBC Science Focus Magazine* paying £17.95 every 6 issues – saving 50%***

YOUR DETAILS (ESSENTIAL)**

Title ____ **Forename** ____
Surname ____
Address ____
____
____ **Postcode** ____
Home phone no ____
Mobile phone no** ____
Email** ____

☐ **I wish to purchase a gift subscription**

GIFT RECIPIENT'S DETAILS (ESSENTIAL)**

Title ____ **Forename** ____ **Surname** ____
Address ____
Postcode ____ **Home phone no** ____
Mobile phone no** ____
Email** ____

Instructions to your bank or building society to pay by Direct Debit DIRECT Debit

To: the Manager (bank/building society)
Address
Postcode
Name(s) of account holder(s)
Bank/building society account number ☐☐☐☐☐☐☐☐
Branch sort code ☐☐☐☐☐☐
Reference number (internal use only) ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
Originator's identification number
4 4 3 7 7 3

Please pay APS RE Our Media Ltd debits from the account detailed in this instruction subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction may remain with APS RE Our Media Ltd and, if so, details will be passed electronically to my bank/building society.

Signature
Date / /

Banks and building societies may not accept Direct Debit mandates from some types of account

KEEP IN TOUCH

****BBC Science Focus Magazine* would like to send you updates, special offers and promotions by email. You can unsubscribe at any time. If you would like to receive these, please tick here ☐**

We'd also love to tell you about other offers and promotions from our publisher, Our Media Limited. If you'd rather not be contacted this way please tick here: ☐ Post ☐ Phone. For information about how we use your personal data, and to change the way we contact you, see our privacy policy, which can be viewed online at policies.ourmedia.co.uk/privacy-policy

OTHER PAYMENT METHODS

☐ **UK cheque/credit/debit card – £62.89 for 14 issues, saving 25%**
☐ **Europe inc Eire – €114.00 for 14 issues**
☐ **Rest of world – $137.00 for 14 issues**
☐ **I enclose a cheque made payable to Our Media Ltd for £** ____

Visa ☐ **Mastercard** ☐ **Maestro** ☐
☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐
Issue no ☐☐ **Valid from** ☐☐☐☐ **Expiry date** ☐☐☐☐

Signature ____ **Date** ____

If credit card address is different, please use the order hotline 03330 162113

OVERSEAS Please complete the order form and send to: *BBC Science Focus Magazine*, PO Box 3320, 3 Queensbridge, Northampton, NN4 7BF

*Offer ends 09 July 2024. 50% saving is only available to UK residents paying by Direct Debit. Overseas rates are available. Personal subscriptions will start with the next available issue.

You may photocopy this form

EASY WAYS TO ORDER

SCAN ME

ONLINE
ourmediashop.com/SFP406

PHONE
03330 162113†
(please quote SFP406)

POST
FREEPOST OUR MEDIA
(please write in capitals)

†UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages, call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 9am-5pm. If calling from overseas, please call +44 1604 973721.

FSC www.fsc.org MIX Supporting responsible forestry FSC® C015155

SPECIAL SUBSCRIPTION OFFER!

SAVE 50%

WHEN YOU SUBSCRIBE TO *BBC SCIENCE FOCUS MAGAZINE* TODAY*

- **Save 50% on a subscription**
- **Pay just £17.95 every 6 issues** by Direct Debit!*
- **Receive every issue** delivered direct to your door with **FREE UK delivery**
- **Stay up-to-date** with the fast-moving world of science and technology

Science Focus
THE MENTAL HEALTH ISSUE
A BLUEPRINT FOR ANTI-AGEING
GET MORE TIME
SOMETHING IS WRONG WITH OUR MODEL OF THE UNIVERSE...
HERE'S WHAT HAPPENS AT
THE HUNGER GAME
The hidden rules of appetite and how they work against you
OBSESSION
EARTH'S MYSTERIOUS CORE
THE SECRET LIFE OF DOGS
AI

~~£5.99~~
PAY JUST £2.99*

TAKE-OFF AT

LAST

Eviation's commuter plane Alice is one of the many electric planes currently being developed

EVIATION

AFTER A LONG WAIT, THE WORLD'S FIRST ZERO EMISSIONS AEROPLANES ARE FINALLY TAXIING TO REALITY. BUT ARE THEY THE SOLUTION WE NEED?

by **IAN TAYLOR**

The future of human flight arrived quietly, at a time when no one was clocking up air miles. It was June 2020 and the skies were unusually empty as the world reeled at the speed of the COVID-19 outbreak. But down on the ground, something pretty huge was happening with a very small aircraft.

EASA, the European Union Aviation Safety Agency, certified a two-seater plane made in Slovenia as safe to fly. Within a few years it was certified by equivalent bodies in the UK, the US and elsewhere. The Pipistrel Velis Electro became the first fully certified electric aircraft in the world. It's still the only one. "The achievement represents a growing interest and trust in the reliability of electric aircraft," says Dr Tine Tomažič, director of engineering and programmes at Pipistrel. "We recently completed production of our 100th Velis Electro, marking a significant milestone for Pipistrel and the industry."

The future is already here, says Tomažič, but to borrow a line from sci-fi author William Gibson, it's far from evenly distributed. Despite a growing number of cleaner aircraft in development, there remain big questions about the alternative fuels required to fly them, and more still about the political will to make it all happen. After several abandoned take-offs, is this the moment that air travel finally goes green? Or is zero-carbon flight still the stuff of blue-sky thinking?

CLIMATE IMPACT

"Right now, aviation isn't a major contributor to climate change," says Dr Guy Gratton, somewhat unexpectedly. Gratton is associate professor of aviation and the environment at Cranfield University in the UK. An aeronautical engineer by trade, he's also a test pilot who flies experimental electric aircraft – in other words, he knows what he's talking about.

"Aviation is generating around two and a half per cent of global carbon, which is small, particularly when you consider its importance to the global economy," Gratton says. "There is science which is suggesting that the contribution through contrails may be rather worse than that, so it's perhaps up to around seven per cent."

The industry is improving its emissions by roughly two per cent per passenger mile per year, Gratton says. But it's also growing by five per cent a year. The global demand for air transport is estimated to double by 2040, which means that while other industries are showing meaningful signs of decarbonising in the face of the →

VELIS
ELECTRO
S5-PII01
PIPISTREL
EASA TYPE CERTIFIED

TEST-FLYING ALTERNATIVE FUELS

HOW DO WE FUEL THE FLIGHT TO NET ZERO AIRCRAFT?

Biofuels

Derived from crops and other biomass, biofuels can be mixed with existing jet fuels, but at best will only offer a 40 per cent saving on emissions, says Dr Guy Gratton, and there are related concerns over the land and deforestation required to produce them.

Electrofuels

Made by scrubbing CO_2 and carbon monoxide from the atmosphere and combining it with hydrogen. A promising solution, but still at an experimental stage and, if scaled up, would require a lot of renewable electricity for true net zero production.

Electric fuel cells

Already in use on some (mostly prototype) aircraft, these batteries are comparable to those used for electric cars. While they don't produce emissions in flight, creating the technology is power-intensive and the batteries themselves need to be replaced.

Hydrogen fuel cells

Heralded by some as the best medium-term option we have for decarbonising aviation, hydrogen fuel cells could be scaled up to work with larger aircraft. Those aircraft and the infrastructure supporting them would need to be radically redesigned around the new fuel, however.

→ climate crisis, aviation is on track to increase its total emissions and, in the process, become one of the world's worst polluters. "In order for us to continue to keep the massive social and economic benefits aviation brings the world, we need to fix that and stop aviation from becoming a majority polluter in the future," Gratton says. "Now, how can we do that?"

SMALL STEPS

The Velis Electro is leading the way, but the first electric planes aren't designed to replace large passenger aircraft. The majority don't have the range to cross the English Channel, never mind the Atlantic. Instead, these pioneer aircraft are built for short flights. The Velis Electro is designed specifically for flight training, offering 50 minutes of flight time with 20 minutes reserve and a range of 100 nautical miles (185km). It's powered by a 58kW electric motor with two lightweight lithium batteries, which are game-changers. The problem with traditional batteries is that they're either too heavy or too hot (or both) to be safe or practical for an aircraft. Pipistrel's system, however, makes the whole powertrain safe, light and efficient.

"The powertrain is entirely liquid-cooled," says Tomažič. "It has demonstrated levels of safety equivalent to, or higher than, conventionally powered aircraft." The battery weighs 70kg (154lbs) and the whole aircraft weighs just 425kg (936lbs) when empty. But if the underlying technology is revolutionary, the cockpit is familiar and the controls are similar to conventional aircraft of the same size. Pilots don't need an additional license to fly the Electro, but they will notice some →

TOP The two-seater Velis Electro, made by Slovenian company Pipistrel, is the first electric aircraft to be certified by the EU's Aviation Safety Authority

ABOVE The cockpit of the Velis Electro looks the same as a conventional plane of this size, but without the usual engine noise is much quieter for anyone flying in it

OPPOSITE Current electric planes have relatively short ranges, so tend to be used for training or short-haul flights

PIPISTREL X3

→ differences, Tomažič says. For starters, there's no engine warm-up and much less noise. "The aircraft delivers power instantly and without hesitation," he says. "It uses a simplified user interface in a cockpit that maintains the same look and feel of its conventionally powered siblings. The cockpit is also much quieter than with conventional aircraft, which spurs better communication possibilities."

Pipistrel's future plans include a four-seater Electro with a range of 200 miles (370km) and it's also working with the EU on a project called the Unifier 19. "It's an EU initiative to develop a community-friendly, low noise and carbon emissions 'mini liner' to connect remote areas within Europe," says Tomažič.

The Velis Electro will soon be joined in the sky by other electric aircraft. The Alice, from Israeli company Eviation, is a nine-seater 'commuter' plane that took its first prototype test flight in 2022. Meanwhile, the E9X concept aircraft from Dutch start-up Elysian Aircraft is scheduled to fly in 2033. With batteries integrated into the plane's wings, it's hoped to carry 90 passengers some 430 miles (800km). And Wright Electric (yes, named after the Wright Brothers) is a US start-up developing an electric 180-seater airliner in partnership with EasyJet. As someone who tests electric aircraft, Gratton is

ELYSIAN
E9X

“BATTERY-POWERED AIRCRAFT WILL FIX A PRETTY SMALL PART OF A BIG AND GROWING PROBLEM”

cautious about hailing battery-powered planes as the answer. They may cut the carbon emissions of celebrities jetting from penthouse to music festival. They’ll also cover short-haul routes between cities, such as London to Edinburgh or Jeju to Seoul in South Korea – the busiest domestic flight route in the world. But short-haul flights account for less than 20 per cent of aviation’s overall carbon emissions. If battery technology doesn’t scale up to cover medium- and long-haul flights, then battery-powered aircraft will fix a pretty small part of a big and growing problem.

“They’re probably a necessary step on the route to other solutions,” Gratton says. “But they’re not going to solve it for the simple reason that the batteries we have aren’t good enough and they’re not projected to be good enough.”

AN ALTERNATIVE

Another option is hydrogen fuel, which can work in a couple of ways. Hydrogen could be burned in a turbine engine to produce thrust, or hydrogen fuel cells could generate electricity to power an electric motor. It’s widely considered one of the best options available to decarbonise aviation. The only in-flight emission is water and projections suggest hydrogen planes will account for a third of the industry’s energy demands by the middle of the century.

Some of aviation’s biggest players are heavily invested in the technology. Airbus intends to bring its hydrogen-powered ZEROe airliner concept to market by 2035. It’s also investing in smaller companies like ZeroAvia, based in the Cotswolds. In 2023, ZeroAvia demonstrated the maiden flight of a 19-seater Dornier 228 that it retrofitted with a prototype hydrogen-electric powertrain. It only flew for 10 minutes, but it’s the biggest plane to have ever flown on hydrogen power.

After the test flight, the company’s CEO Val Miftakhov said, “This is a major moment, not just for ZeroAvia, but for the aviation industry as a whole, as it shows that true zero-emission commercial flight is only a few years away.”

No less ambitious is Sirius Jet by Sirius Aviation. The Swiss-based company is developing a hydrogen electric vertical take-off and landing (eVTOL) business jet that can carry three people. It features 28 ducted jet fans that stretch across the plane’s wings, each powered by an electric motor and tilting to switch between regular and vertical flight. Sirius Aviation’s CEO Alexey Popov says the aircraft will have a range of over 1,000 miles (1,800km), travelling at 323mph (almost 520km/h), but it’s the efficiency of the hydrogen fuel stack that he’s most proud of. “In a traditional jet aircraft, you see efficiency of around 30 per cent. In our fuel cell stack, it’s 50 per cent,” he says.

ONE PROBLEM, MULTIPLE SOLUTIONS

Gratton agrees that hydrogen likely has a significant role to play in decarbonising flight, but that’s not to say it’s going to be an easy switch. “Hydrogen looks really good weight-wise,” he says. “It’s pretty equivalent to kerosene, which is what we run jet aircraft on now. But volume-wise, it takes up a lot more space. If we’re going to go down the hydrogen route, then we would basically need new aircraft. You would need to be designing new airliners, new engines, new fuel systems, new ways of distributing fuel to airports.”

And that’s true of any solution. In 2023, Gratton contributed to a sobering report by the Royal Society on the future of green air travel and what would be required to hit the UK’s net zero targets. It found that “there is no single, clear, sustainable alternative to jet fuel able to support flying on a scale equivalent to present-day use.”

Assessing costs, available resources and other factors, it laid out the scale of the challenge. Let’s say the world opted for biofuels as the preferred alternative to jet fuel. This is preferable to some because it requires the least amount of adaptation from existing infrastructure and propulsion technology. But just meeting existing aviation demand would require around half of all the UK’s agricultural land to grow the crops. Likewise, to produce enough clean hydrogen fuel, the Royal Society report says we’d have to find somewhere between 2.4 to 3.4 times the amount of renewable electricity generated in the UK by wind and solar in 2020.

So, what’s the answer? Well, all of it, Gratton says. He believes we should be pursuing all forms of alternative fuel because it’s likely we’ll need a mix. That includes so-called electrofuels, a synthetic type of fuel created from captured carbon dioxide and carbon monoxide. So far, this solution only exists in tiny quantities at the laboratory scale, which is why Gratton thinks we should still be building experimental aircraft and different kinds of fuel cells. “It may well be that once they’re mature, these solutions will scale up to bigger aircraft. So doing it is worthwhile.” The age of zero emissions flight has arrived, but making it the norm is still a long-haul challenge. **SF**

by **IAN TAYLOR**

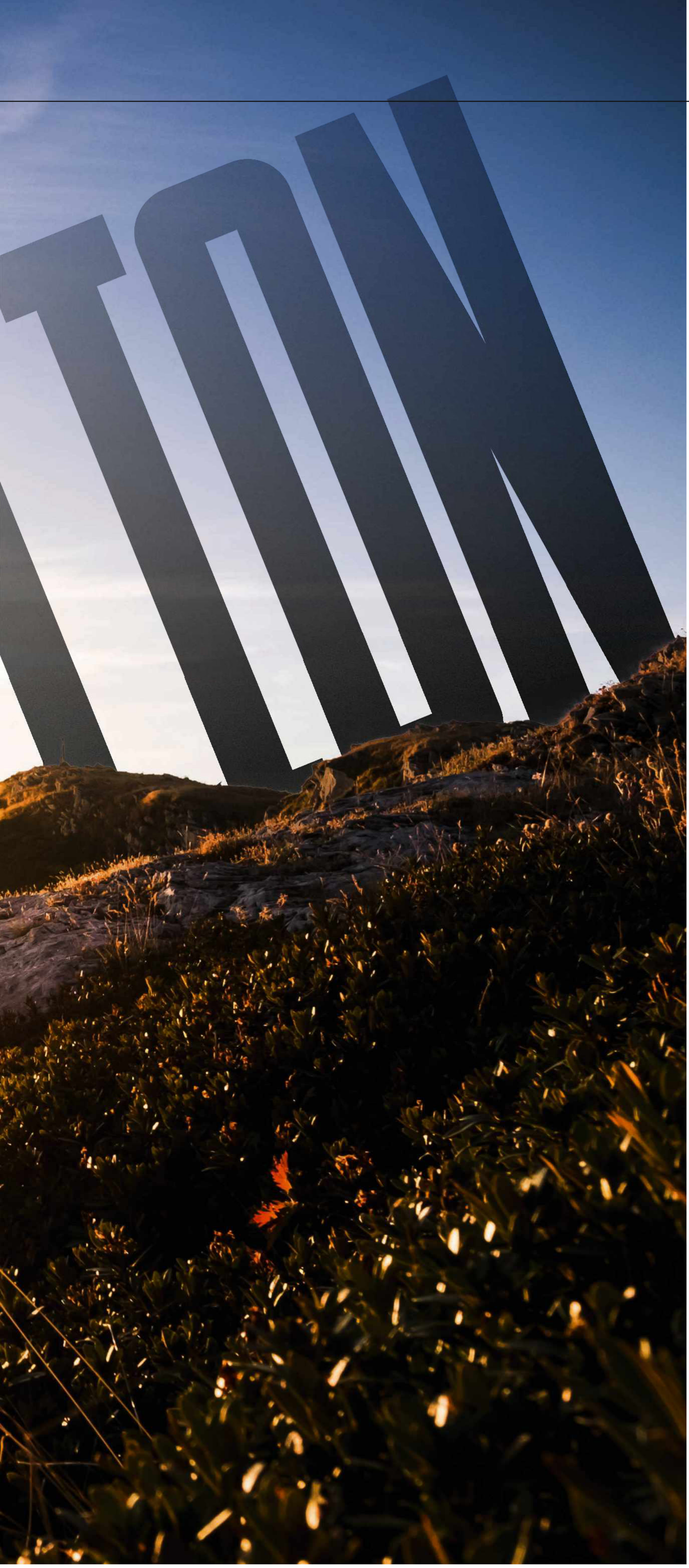
Ian is a freelance science writer and the former deputy editor of BBC Science Focus.

ABOVE Israeli company Eviation is developing its version of an electric plane. The nine-seater aircraft called Alice completed its first flight in 2022

LEFT Dutch start-up Elysian Aircraft has unveiled the E9X, which is hoped will carry 90 passengers distances of up to 430 miles (800km). It’s expected to take to the air in 2033

EVIATION, ELYSIAN

MASTER YOUR
MOTIVAT



GETTY IMAGES

Why are some of us procrastinators while others are dynamic, go-getters? It's down to our brains and by understanding the science behind motivation, you may find you can achieve more

by **JOEL SNAPE**

Here's a quick question. On a scale of 1–10, how motivated do you feel about doing whatever it is you need to do when you finish reading this? And what does that even mean? As humans, most of us are intrinsically driven to pursue a few things – food, shelter, companionship and recognition. But when it comes to more abstract or long-term goals, some people seem endlessly energised while others struggle to get off the starting blocks.

So, what's happening in your brain when you feel motivated? Can you harness that feeling or encourage it to happen more often? And is motivation actually what you need – or can you operate without it?

"From a neuropsychological perspective, the main regions of the brain that take part in motivation are the amygdala and the prefrontal cortex, which need to work with each other correctly for effective action to occur," says Dr Avigail Lev, a clinical psychologist and author of *Acceptance and Commitment Therapy for Couples.*

The amygdala is our emotional centre, she says, while the prefrontal cortex is the area that helps you plan and execute decisions. "The amygdala controls your brain's fear response and can push you towards action. But anxiety works on a bell curve, so if you have too much, you become paralysed and can't get things done."

So, there's an optimal amount of anxiety. This is where the prefrontal cortex comes in. "It helps to plan ahead, breaks things down into smaller steps, and uses our executive functioning and higher-order abilities to come up with an effective way of achieving our goals," Lev says.

INCENTIVE INSIGHTS

The other part of the equation that you're probably already familiar with, if only by name, is dopamine. This neurotransmitter has a crucial role in controlling motivation. The release of dopamine in response to an event signals learning about whether what we experienced was good or →

→ bad. "It helps us to choose which actions to perform to gain the good things and avoid the bad things," says Dr Amy Reichelt, a neuroscientist. "Dopamine in the brain is either released by neurons firing in a steady-state basis or in 'phasic' surges that cause rapid increases or decreases in dopamine concentrations in specific brain structures, including the nucleus accumbens – a key brain region involved in reward and regulation of effort-related functions."

According to Reichelt, a rewarding experience like eating a delicious chocolate bar might trigger a surge of dopamine signalling, but seeing an advert for that delicious chocolate bar, the prediction of a reward, can also have the same effect. Your attention focuses on the possible reward and creates an urge to replicate the initial rewarding experience.

In other words, dopamine isn't just about liking, it's also about wanting and seeking – and as such, it's a key factor in propelling action. It's been shown experimentally, for instance, that animals with depleted dopamine levels in the brain won't perform behaviours that require high effort to gain a reward. Meanwhile, people who were administered amphetamine, which augments dopamine release in the brain, showed an increased willingness to perform an effortful task.

This also means that dopamine signalling can be hijacked. Most popular social media platforms, for instance, are built to encourage it with variable-reward signalling similar to the kind you see in slot machines, encouraging you to spend more time scrolling and liking than you otherwise would.

TYPES OF MOTIVATION

What does this mean for staying motivated? Firstly, and maybe most obviously, it means avoiding the things that motivate you to do things you don't actually want to be doing, like resisting the siren call of social media. It also means finding ways to trigger a dopamine response when you do stuff you *should* be doing – but that's a little bit more complex than it might sound.

"There are two overarching types of motivation: intrinsic and extrinsic," says psychologist Dr Anthony Thompson of Arden University, Coventry. "With intrinsic motivation, people engage with an activity or behaviour because it is inherently interesting – there isn't necessarily any expectation of a tangible reward at the end. In contrast, with extrinsic motivation, people engage in an activity or behaviour for the purposes of gaining a tangible reward – such as money or recognition or avoiding a punishment."

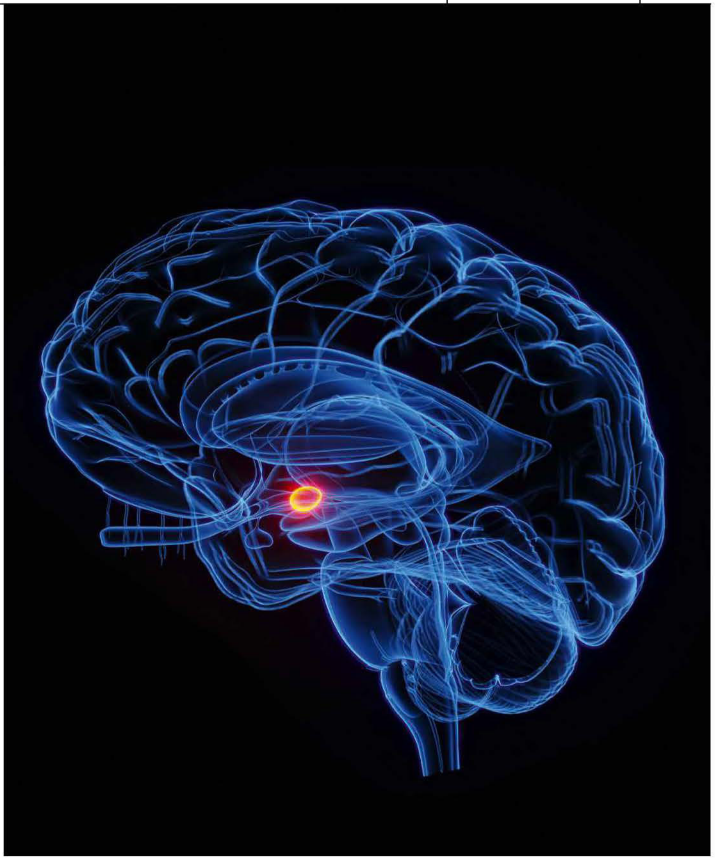
So extrinsic motivation *might* be helpful for starting a new behaviour or motivating yourself to do something you don't find inherently interesting – like treating yourself to an episode of your favourite TV show after

ABOVE The neurotransmitter dopamine plays a key role in the brain's reward pathway

ABOVE, RIGHT Anxiety, a response to fear, is triggered by the amygdala. In the right amount, it prompts decisive action, but too much can leave you unable to act

RIGHT Dr Avigail Lev

"WITH EXTRINSIC MOTIVATION, PEOPLE ENGAGE IN AN ACTIVITY OR BEHAVIOUR FOR THE PURPOSES OF GAINING A TANGIBLE REWARD – SUCH AS MONEY OR RECOGNITION"



GETTY IMAGES X2

you've been for a run, say. But there's an issue. "Research initially viewed intrinsic and extrinsic motivation as being separate, but complementary, processes," says Thompson. "However, studies have shown that extrinsically motivating someone by providing rewards can actually undermine their motivation, making people less interested in tasks that they were initially intrinsically motivated to complete when the reward is removed."

This probably means that if you're looking to stay motivated over the long term, intrinsic motivation is what you need. And if you don't feel naturally curious or energised about whatever it is you're trying to do, it's a good idea to find a way to give it some meaning so that you do.

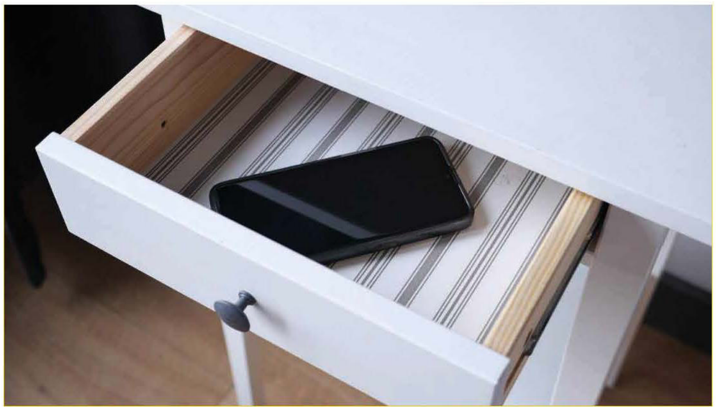
"Intrinsic motivation is enhanced when we feel a significance or purpose to our behaviour," says Lev. "When we feel that our goal is deeply meaningful to us, we're more likely to achieve it." Lev encourages people to clarify their deeply held values and identify what specific actions and behaviours are in alignment with those values.

For example, if you can't bring yourself to go to the gym, it might help to identify a deeply held value of yours that aligns with the behaviour – like, for example, eventually becoming the sort of fun grandparent who can run around a playground with your grandchildren. Similarly, if you really can't face another round of going through emails or attending meetings, have a think about which of your values those tasks are serving – like being a good provider for your family. Above all, put the right systems in place and you'll still be able to get things done.

Over the page are some more tips that could help you with your motivation... →

YOUR 8-STEP GUIDE TO MOTIVATION

Try these simple ideas on how to master motivation and maybe you'll be able to unlock more potential and achieve those goals that have always felt out of reach



1. DUMB DOWN YOUR PHONE

Before you do anything else, minimise the influence of things that are competing for your attention. Your smartphone, for example. Studies suggest that just having a smartphone near you makes you more likely to pick it up. Try keeping it out of sight by leaving it in a drawer or your bag if possible. There are also apps available that will transform your home screen from the colourful, alluring delight it is now to a boring blank screen with nothing but text on it. Turn off notifications for anyone who doesn't need to contact you urgently and consider changing your lock screen to a reminder of what's actually worth worrying about — like your family or that cottage in the Cotswolds you're hoping to own one day.

---

2. SET 'PROCESS' GOALS

"Outcome goals – like wanting to speak Spanish or lose 5kg (11lbs) – are common, but this type of goal tends to lean towards extrinsic motivation," says Dr Anthony Thompson. Outcome goals can be motivating at first due to the anticipatory emotions generated by imagining what it would be like to attain the goal. But they also tend to be long-term, so it's difficult to track or measure progress towards the goal, which can degrade motivation over time. In contrast, process goals focus on the behaviour rather than the outcome. For example, spending five minutes a day learning Spanish shifts the focus to elements that can be monitored and tracked more frequently. "It's easier to track that you've completed 10 minutes of language learning than it is to track the goal of being able to speak Spanish," says Thompson. Individuals receive more regular feedback on progress, which can be motivating.

2:28
duolin
Duolingo - Language Lessons
Duolingo
OPEN
242K RATINGS
4.6
★★★★★
AWARDS
Editors' Choice
Apps
AGE
4+
Years Old
CHART
What's New
Version 6.222.0

3. MAKE GOALS SMALL AND ACHIEVABLE...

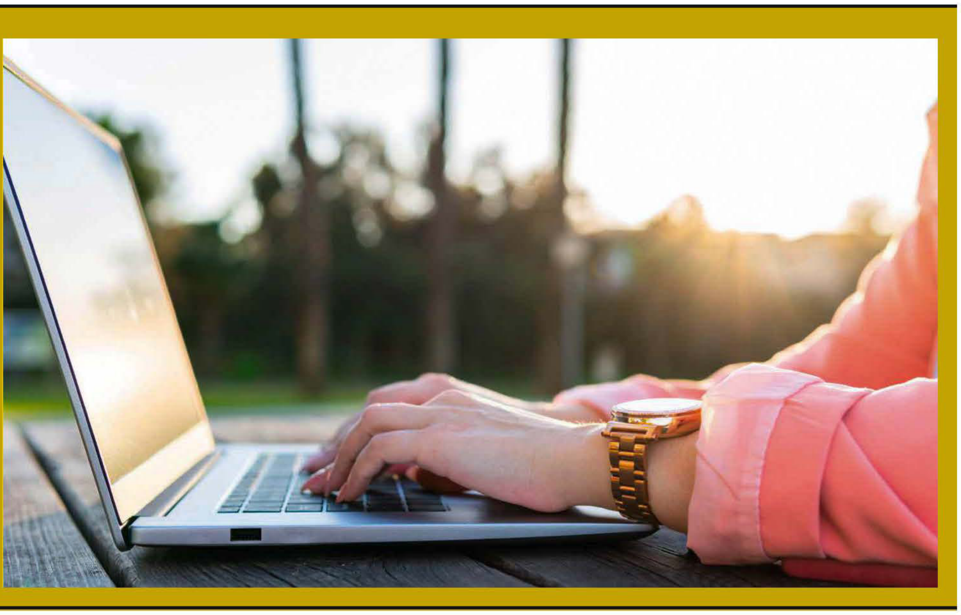
"Your brain releases dopamine every time you experience a sense of achievement, whether it's completing a demanding task, reaching a goal, receiving acknowledgment for your hard work, or mastering something new," says Dr Amy Reichelt. "This further motivates the behaviour that you've been performing. When you set achievable goals and experience small wins along the way, your dopamine system is able to positively reinforce those behaviours, making you more likely to perform those behaviours again to get the same sense of intrinsic achievement." In other words, set yourself small, achievable goals rather than trying to motivate yourself through one long task and celebrate the small wins along the way.

4…AND TIE THEM TO A BIGGER PURPOSE

"The biggest mistake people make is assuming that the pleasure they receive from hitting their end goal will last," says Dr Emma Seppälä, a psychologist and lecturer. "Unfortunately, that's just not the case because the dopamine high is only momentary, and you're left craving more. This is the brain's way of ensuring we keep reproducing, eating, seeking recognition and so on." According to Seppälä, there's one form of pleasure that doesn't subside so quickly and that's the pleasure we receive from doing something for others – compassion and altruism, and connecting with something bigger or beyond ourselves. In essence, the pleasure that offers a quick dopamine rush, known as hedonic pleasure, is centred around personal gratification, while the pleasure that endures, eudaimonic pleasure, is derived from actions that serve a greater purpose. So, you'll be more motivated if you chase higher goals, but also if you tie your existing goals to a higher purpose.

5. USE THE TWO-MINUTE RULE

"This rule, popularised by David Allen [productivity expert and author of *Getting Things Done*], works because it prevents small tasks from accumulating to the point where they feel overwhelming and unmanageable," says Dr Kristin Mann, an organisational psychologist. "If a task takes two minutes or less to do, do it straightaway." It could be sending an awkward follow-up email or wiping down the sink, but you could also expand it to a habit you're trying to start, such as playing the piano or reading one page of a book. Just do the smallest amount you can.



6. THINK AHEAD

"When you're looking at your alternatives, like staying on the couch or going to the gym, do a mental experiment," says Seppälä. "Imagine how you'll feel after doing both things for an hour – probably lethargic, lazy and a little down on the sofa, or accomplished, energised and happy at the gym. Or if you're trying to cut down on sugar and you see a slice of cake, consider how you'll feel after you've eaten it."

7. TRY 'BACKCASTING'

Imagine yourself at 75 – healthy, wealthy and sitting in your garden sipping a cool drink. Great! How did you get there? Poker player Annie Duke calls this way of thinking 'backcasting.' In one experiment, researchers found that imagining an event has already occurred increases people's ability to correctly identify reasons for that outcome by 30 per cent. So link your long-term goals to short-term actions and you're on your way.

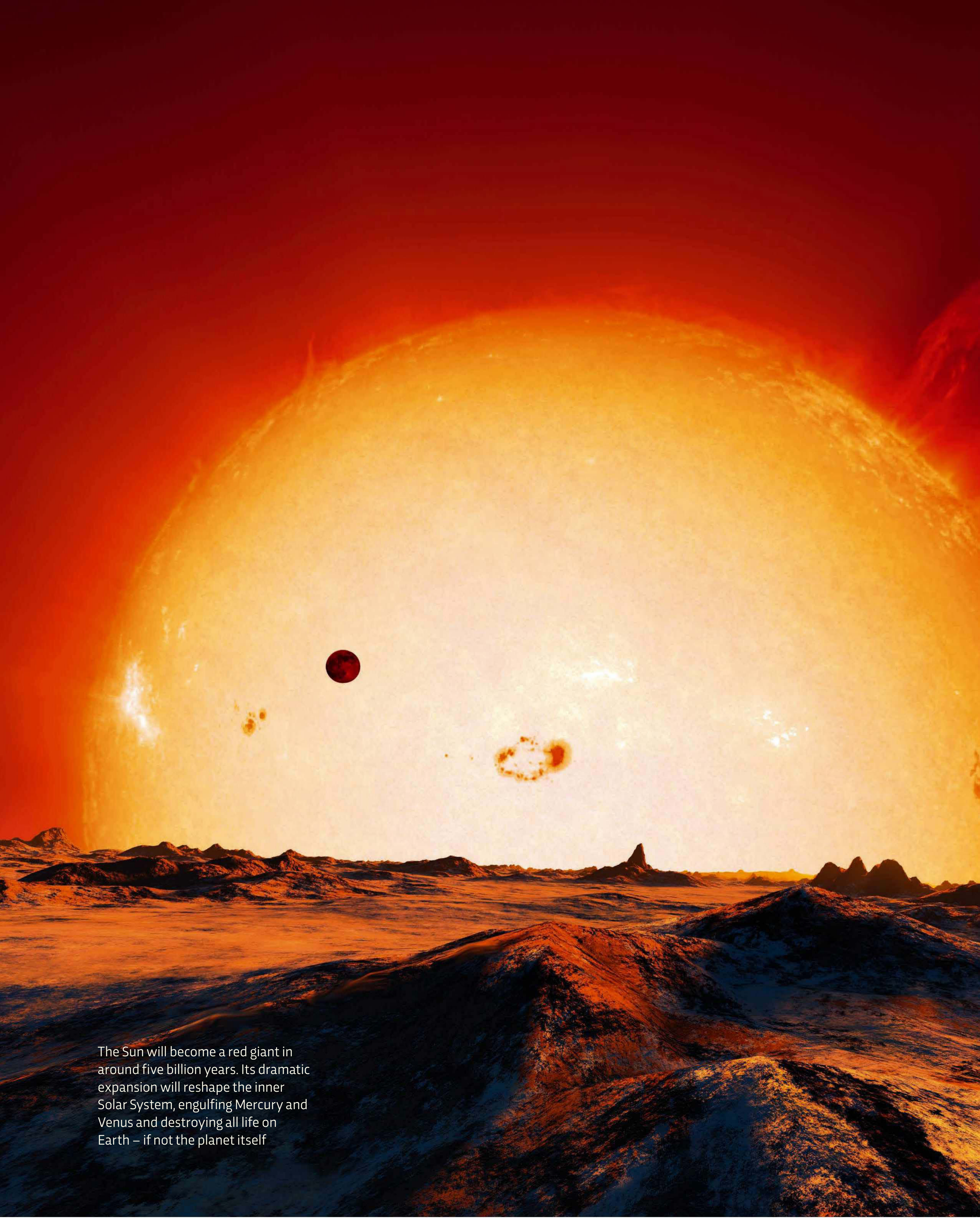
8. GET MOVING

It's tempting to think that you need to be motivated to start an exercise programme, but, in fact, that might be thinking about things the wrong way around. "Tonic dopamine levels may be increased by engaging in physical activity and exercise," says Reichelt. "This might help recalibrate your baseline dopamine, so it's less effortful to motivate yourself to complete a task that has been lurking on your to-do list for a while." If a full-bore workout seems too intimidating, just a handful of squats or a quick walk over your lunch hour might do the trick.

by **JOEL SNAPE** *(@JoelSnape)*

Joel is a science and health writer. He runs a YouTube channel focused on the science of skill acquisition.

GETTY IMAGES X5, ALAMY X2



The Sun will become a red giant in around five billion years. Its dramatic expansion will reshape the inner Solar System, engulfing Mercury and Venus and destroying all life on Earth – if not the planet itself

SCIENCE PHOTO LIBRARY

HOW THE UNIVERSE WILL END

A colossal supercollider now in the early stages of development may one day help us predict the ultimate fate of the Universe. With it, scientists will be trying to find a hidden instability built into the fabric of existence... an instability that could destroy everything

by **DR ALASTAIR GUNN**

Most cultures have stories and myths detailing the end of days, from the eventual fate of humans to what will happen to our world and any other realms inhabited by their respective deities. These legends often promise the arrival of a reorganised existence after the cataclysm, a paradise.

But what does modern science have to say about the end of days – or to put it in more scientific terms, the end of the Universe?

We know that Earth, if it's not destroyed by us or an errant asteroid first, will likely be incinerated when the Sun expands into a red giant. Luckily, that's not likely to happen for at least another five billion years.

As for the Universe as a whole, do we have any understanding of when and how it will come to an end?

We can look to modern cosmology for some intriguing possible answers. And with the European Organisation for Nuclear Research, aka CERN, currently developing the Future Circular Collider (FCC) – a gargantuan 'atom smasher' almost three times bigger than the Large Hadron Collider (LHC) – we're one step closer to knowing which one is likely to be right.

FREEZE, CRUNCH OR RIP

In exploring the various theories, it all comes down to the balance between the expansion of the Universe and the pull of gravity. In one scenario, gravity may not be strong enough to stop the Universe from expanding, meaning it'll continue to do so forever.

As all the energy eventually becomes uniformly distributed, the Universe will become darker and colder. Even black holes will evaporate as the Universe becomes a near-vacuum of subatomic particles and photons, an endless and timeless void where nothing ever happens. This is called the 'Big Freeze' (or, conversely, 'Heat Death').

But, according to a second theory, if gravity is strong enough to overcome expansion then the Universe will one day start to contract again. Eventually, it'll collapse in on itself to eventually become a compact fireball, before vanishing into the 'singularity' from which it came. The 'Big Crunch', as it's called, will swallow all matter and energy, as well as space and time.

To determine which of these possibilities will happen, astronomers need to know the expansion rate of the Universe (and how it changes over time), as well as its total matter and energy →

→ content. This amounts to knowing the 'shape' of the Universe, which can be found with the cosmic microwave background, the relic afterglow of the Big Bang. As sound waves moved through the early Universe, there were small variations in temperature, and the size of these hot and cold spots depended on the geometry of space. It's something akin to taking a vast trigonometry measurement across the entire cosmos. The results show that the Universe is almost certainly 'flat', meaning that its density is just sufficient to halt the expansion after an infinite time.

A third theory concerns the mysteries of 'dark energy.' Astronomers have found that the expansion of the Universe is actually accelerating due to dark energy, and if this acceleration continues the expansion will overcome all the forces of nature. The result will be the 'Big Rip.' All matter, and space-time itself, will be ripped apart and destroyed. Estimates say this could happen in about 22 billion years.

INSIDE THE GOD PARTICLE

Yet, there's another, and more ominous, way that the Universe may end. This is called the 'Big Slurp' and its likelihood depends not on the vastness of the Universe, but on one of its tiniest components: the Higgs boson.

To understand the 'Big Slurp', we need to enter the quantum world. Quantum theory shows that all particles in the Universe are local excitations, or fluctuations, of quantum fields. Each of the 12 known matter particles has its own quantum field, and there are also fields for the four fundamental forces of nature (namely: gravity, electromagnetism, the strong nuclear force and the weak nuclear force). So, for example, photons (light particles) are fluctuations of the electromagnetic field.

The Higgs boson – termed the 'God particle' because it's the reason that matter has mass – is the particle associated with the Higgs field. All elementary particles (except photons and gluons) are endowed with mass by their interactions with the Higgs field. Solid objects, including you, are only solid objects because of it.

First postulated by the physicist Prof Peter Higgs and his colleagues in 1964, the Higgs boson was discovered in July 2012 by scientists at CERN's current atom-smasher, the LHC. The particle they found weighed 125.1 gigaelectron volts (GeV), which is about 133 times heavier than the proton. It was a scientific breakthrough that gave new credence to our theories of the Universe.

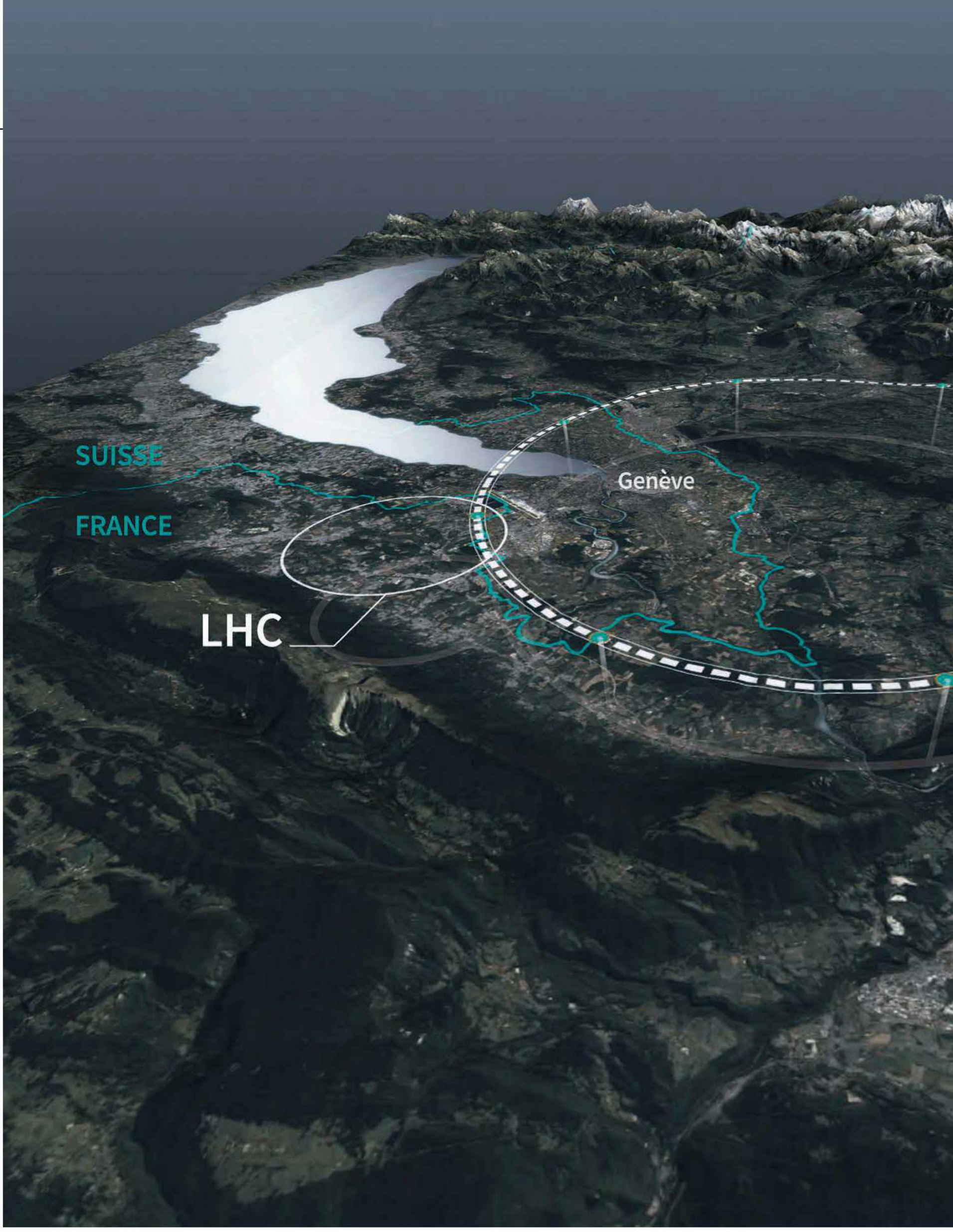
"Colliders are the most powerful microscopes we have to study nature at the smallest scales and during the early moments of the Universe," says Prof Christophe Grojean, a leading physicist at the Deutsches Elektronen-Synchrotron (DESY) research centre in Germany, who specialises in the Higgs boson. "The properties of particles and forces, in the quantum world, have determined how the Universe at large has evolved."

But soon after its discovery, scientists found a worrying problem with the Higgs boson: the particle's mass appears to be perilously close to giving it an inherent instability. An instability that just might be the thing that spells the end of the Universe.

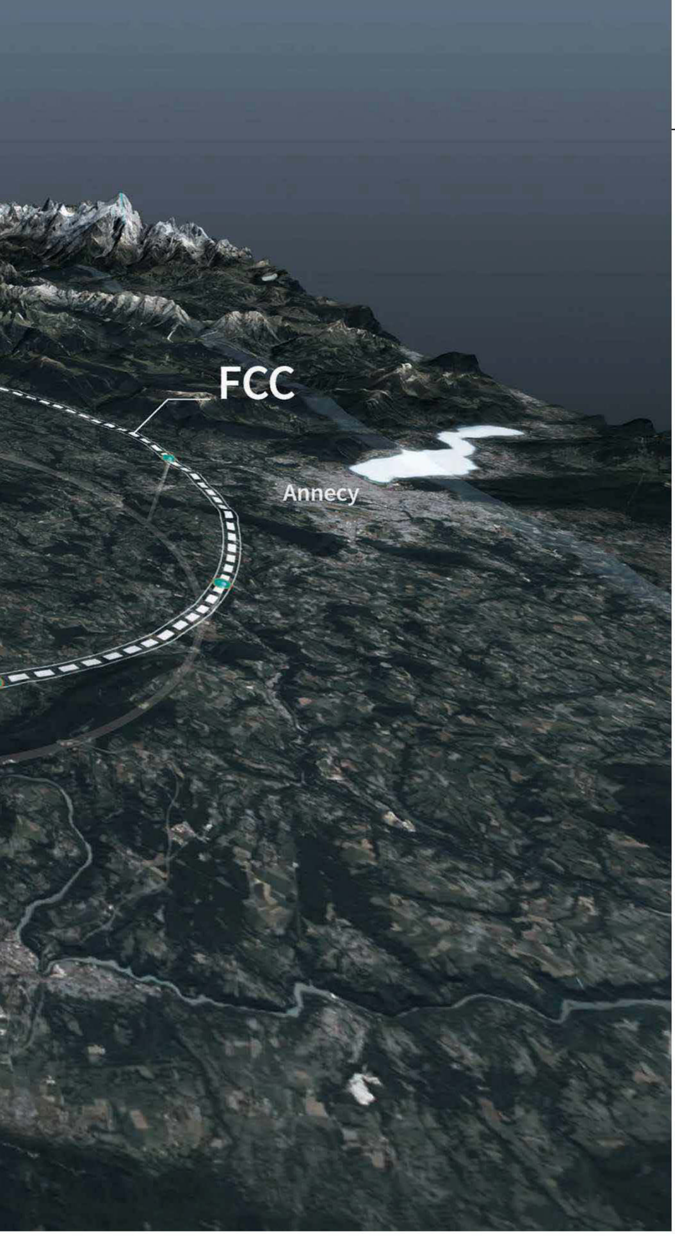
LIVING IN A FALSE VACUUM

It turns out that the Higgs field always has some value associated with it, even when no Higgs particles are present. There's a background, non-zero 'vacuum energy.' Physics requires that the vacuum energy sits at a minimum in the absence of particles, but the trouble is that there isn't a single minimum in the energy of the Higgs field.

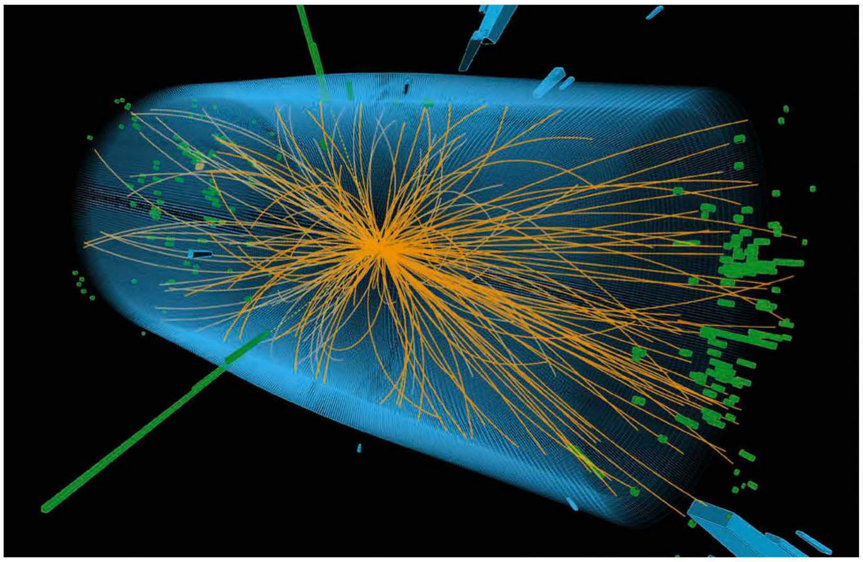
Imagine a ball rolling into a valley and, on the way, it gets trapped in a gully. While the ball may be stable in the gully, it hasn't attained its minimum energy by reaching the valley floor.



ABOVE A schematic map from CERN shows the potential location of the Future Circular Collider, which will dwarf the Large Hadron Collider



“THE HIGGS BOSON’S MASS APPEARS TO BE PERILOUSLY CLOSE TO GIVING IT AN INHERENT INSTABILITY”



ABOVE A representation of the results of particle collisions inside the Large Hadron Collider. This image was released in 2015, after CERN scientists got their most accurate measurement of the mass of the Higgs boson to date

The Higgs field can be trapped in just such an energy gully, rather than the lowest-possible energy state. Physicists refer to this as a ‘metastable’ state and describe the resulting background energy as a ‘false vacuum.’

At the very moment of the Big Bang, the Universe was so hot and dense that the Higgs field didn’t operate. It was zero everywhere and no particles had mass. Then, almost instantaneously, the Higgs field flipped on, giving matter its substance and starting the processes we see governing nature today, allowing us – and everything else – to exist.

The question is whether the Higgs field flipped into its lowest energy state or was trapped in a metastable state. Our best measurements to date suggest the latter, implying that we’re living in a Universe with a false vacuum.

That raises a further question: what if the Higgs field suddenly flipped to a lower energy state? “The Higgs field sets the size of atoms, ensures the proton is lighter than the neutron and guarantees the stability of matter,” says Grojean. “So, a vacuum decay would be bad news for the Universe.”

There would be completely different constants of nature, where physics, chemistry and biology would work in totally different ways, if at all. The Universe would collapse into an entirely new state, destroying and recreating itself in a puff of energy. What that new Universe might look like we have no way of telling and, of course, we wouldn’t be around to find out. This is the fate that would befall us in the Big Slurp.

A vacuum decay could be triggered with enough energy concentrated in a small enough volume. But calculations suggest there’s no known process for achieving this. “The decay rate could have been much faster in the early Universe”, says Prof John Ellis of King’s College London and a veteran of the CERN Department of Theoretical Physics. “So, it’s a puzzle that the vacuum didn’t decay a long time ago.”

There’s one last twist, however. The Higgs field is subject to the rules of quantum physics and there’s a process, called ‘tunnelling’, which allows the Higgs field to jump spontaneously to a different energy state. It’s as if that ball trapped in the gully simply tunnels right through the ground to escape. →

FCC STUDY AT CERN X2

→ While quantum tunnelling can't be predicted because it's a random process, we can calculate the probability of it happening. Thankfully, it turns out to be extremely unlikely, occurring perhaps once in 10^{100} years (1 followed by 100 zeroes). The age of the Universe pales into insignificance in the face of those odds.

Does that mean we're safe after all? Well, just because something happens rarely, doesn't mean it can't happen. Needless to say, physicists would like to find out whether the Higgs field is indeed in a metastable state and, hence, what the eventual fate of the Universe may be.

LOOK TO THE FUTURE

To get to the root of this problem, scientists need to measure, with sufficient accuracy, the Higgs mass, the top quark mass and the 'strong coupling constant.' The latter describes the strength of the strong nuclear force, which holds atomic nuclei (and quarks) together. These values determine the shape of the Higgs' energy valley.

Experiments at the LHC have determined the mass of the Higgs boson with a precision of about 0.1 per cent. The mass of the top quark is known to an accuracy of almost 0.2 per cent, while the strong coupling constant is known to better than one per cent. But for a full investigation, scientists require an order of magnitude improvement in the sensitivity and resolution of the atom smasher. This is where the FCC comes in.

CERN hopes the FCC, which will be the largest and most powerful supercollider ever built, will take over from the LHC in the quest to understand the quantum world. Like its predecessor, the FCC will generate head-on collisions between particles. Two particle beams will be sent in opposite directions through ultra-high-vacuum rings, accelerated to almost the speed of light by strong superconducting electromagnets. The beams then collide in one of the detector instruments, creating a cascade of other particles that are measured and analysed.

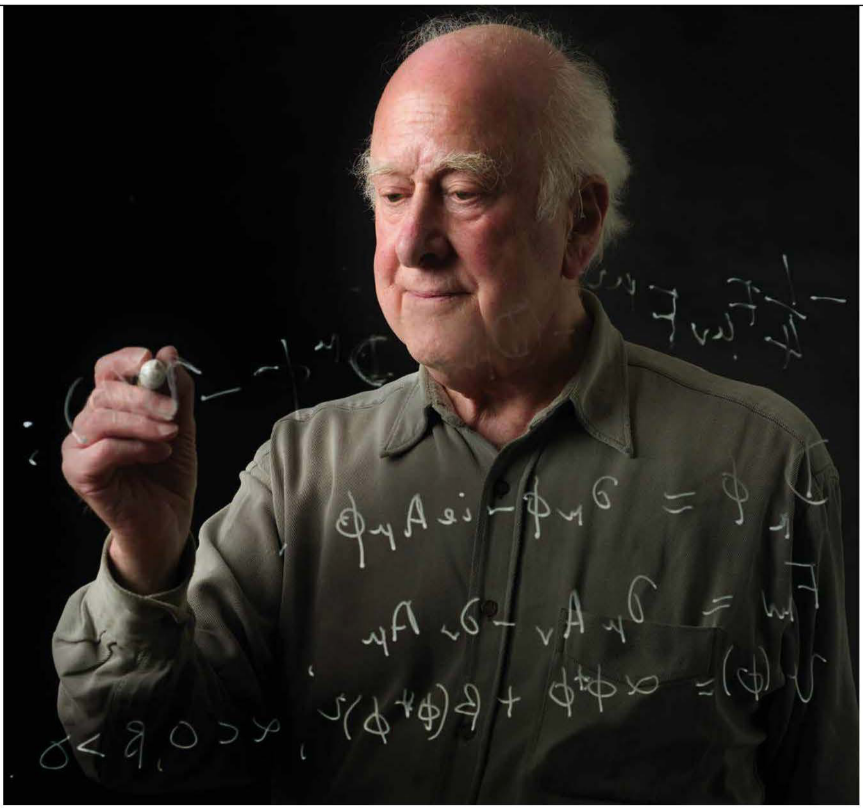
The FCC will occupy a new circular tunnel with a 90km (56-mile) circumference and span the French-Swiss border at an average depth of 200m (650ft). Eight surface sites will allow four instruments to tap into the swarm of high-speed particles that are accelerated around the ring. When the FCC starts colliding particles – which will be, if all goes to plan, in the mid-2040s – the tunnel will house an electron-positron collider. A second instrument, a hadron-hadron collider, will be installed in the same tunnel by the 2070s.

Since energy and mass are related through Albert Einstein's famous $E = mc^2$ formula, the more energy the collider particles have, the higher the mass of the collision 'products.' Many of the problems in modern particle physics involve heavy particles (such as the Higgs boson), so physicists are keen to build bigger and more powerful colliders.

The current maximum collision energy of the LHC is around 13.6 teraelectron volts (TeV). The second incarnation of the FCC (hadron-hadron) will have a maximum collision energy of about 100 TeV. Despite this, there's no danger the FCC will trigger a vacuum decay, as its energy is a mere billionth of what would be required.

"Probing the vacuum instability hypothesis isn't among the key drivers of the FCC," says Grojean, who is directly involved in the development of the instrument. "But it will improve our knowledge of the intimate structure of matter and help decipher the nature of space-time at the smallest scales."

With all the unknowns around the Higgs field – some scientists believe there must be some error in our calculations and that it isn't in a metastable state at all, while others believe there must be undiscovered physics that would remove the instability – the FCC is our best bet for resolving them.



"A REORGANISATION OF THE UNIVERSE MAY ALREADY BE TRAVELLING OUT FROM THE SITE OF THE COLLAPSE"

ABOVE British theoretical physicist Prof Peter Higgs won the Nobel Prize for his work on the particle that bears his name, which was first observed in 2012

CERN X2

DEATH BY BUBBLE

So, while work continues to develop the FCC, we are left with the question: what would actually happen if the Higgs field did suddenly change and cause a vacuum decay? "Physics and cosmology would be completely different, making life impossible. The Universe would collapse upon itself. All objects in the Universe would cease to exist," warns Prof Ellis.

Theory shows that a bubble would form, inside of which the existing laws of nature have collapsed and new ones formed. Matter and energy have transformed or disappeared. The fundamental forces of nature are different, or no longer exist. The bubble expands, racing through the Universe at the speed of light, destroying everything in its path.

And there's always the possibility that, somewhere in the Universe, such a cataclysmic vacuum decay may already have happened. A reorganisation of the Universe may already be travelling out from the site of the collapse. We're just waiting for it to arrive and we wouldn't see it coming.

In his classic 1978 sci-fi comedy *The Hitchhiker's Guide to the Galaxy*, the author Douglas Adams wrote: "There is a theory which states that if ever anyone discovers exactly what the Universe is for and why it is here, it will instantly disappear and be replaced by something even more bizarre and inexplicable. There is another theory which states that this has already happened." It seems Adams could well have been right, on both counts.

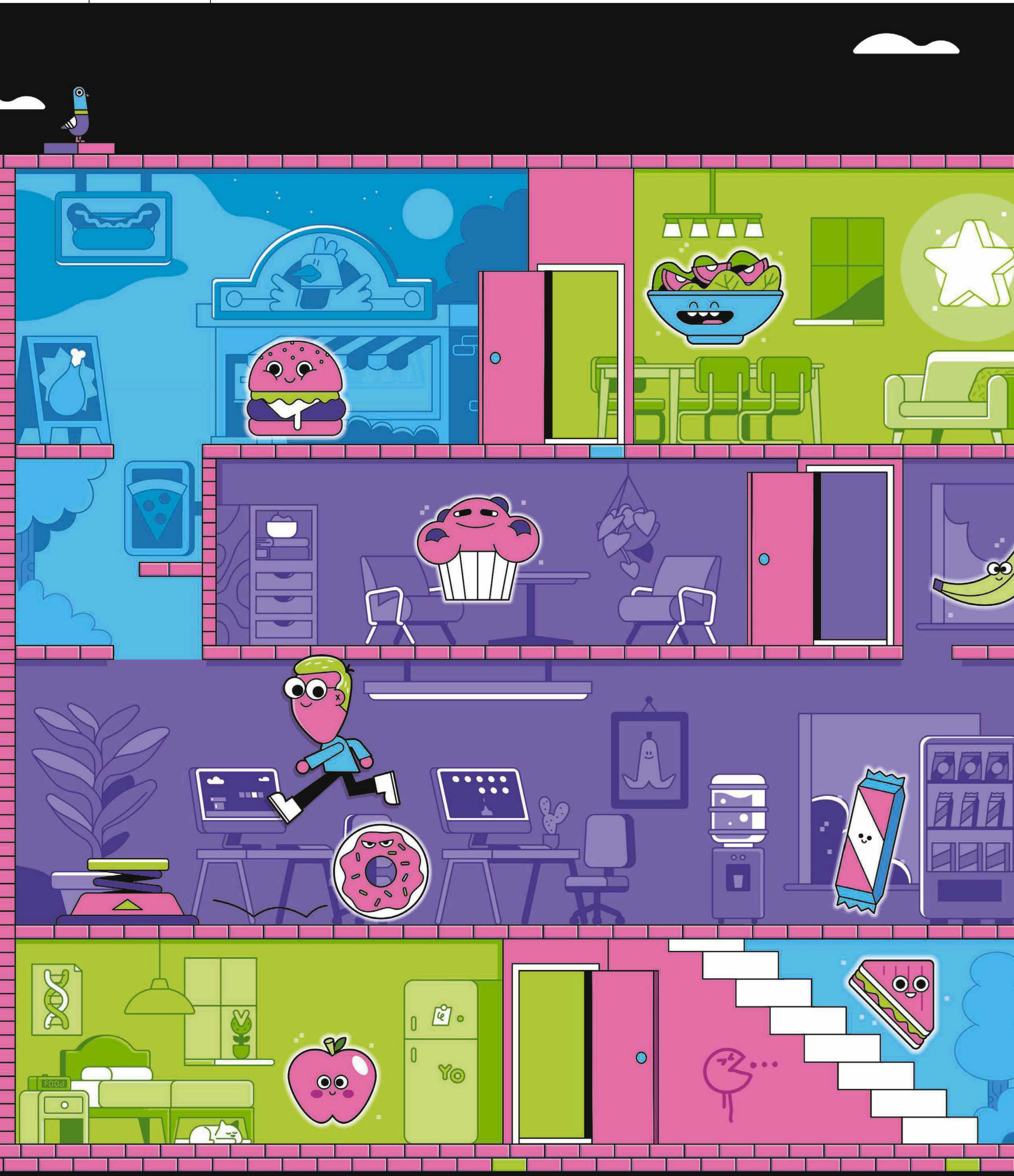
Terrifying as that might sound, though, there's really no need to lose any sleep over a potentially imminent vacuum decay of the Universe. At least, that's based on the time frame put forward by Ellis.

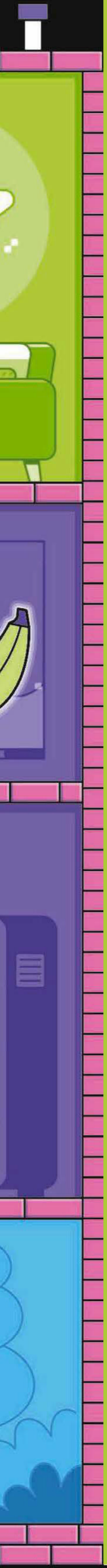
"Spontaneous vacuum decay would occur far in the future, long after the dying Sun eats up the Earth."

Nevertheless, it would be nice to know whether the Universe is in a stable or metastable state. Hopefully, by the time we reach the halfway point of this century, the FCC will be able to provide some clues. **SF**

ABOVE Technicians work on improving the Large Hadron Collider's hardware during one of its shutdowns in between experimental runs

by **DR ALASTAIR GUNN**
(@AlastairGGunn)
Alastair is a radio astronomer at the Jodrell Bank Centre for Astrophysics at the University of Manchester.


Yo



THE HUNGER GAME

Obesity is on the rise, but as we blame our unhealthy food-ridden environment and look to wonder drugs to get rid of unwanted fat, what role do our genetics play?

by
PROF GILES YEO

ILLUSTRATION: PATSWERK

I am a geneticist, which, last time I checked, is a perfectly upstanding profession. I mean my mother-in-law still speaks to me, so that must be a good thing, right?

And yet, when I reveal that I study the genetics of body weight and that your genetics can be the driving cause of obesity, I become a bad person. I'm perceived as giving overweight or obese people – terms I don't use in a pejorative fashion – an excuse.

This has always been an interesting take for me. If I were studying something else, like the genetics of cancer, dementia, arthritis or any other disease, would I suddenly be giving the people who are suffering from those conditions an excuse? I'd hope not. Instead, I hope that people would understand that I'm trying to understand biology and mechanisms, and, shocking I know, I might even be trying to help some of them.

IT'S IN THE GENES

When we talk about body weight, it's all too often considered to be a matter of lifestyle', a habit, a lack of willpower, a choice. The reality is that while rapid changes in our food environment and lifestyle have undoubtedly driven up the obesity figures worldwide, there are many people who are skinny and others who aren't. There's clearly a large variation in body weight, even in the 'obesogenic' environment we live in today (one that promotes weight gain). A large part of this, although by no means all, is down to genetics.

Much of the evidence for a genetic basis to body weight has come from the study of twins. There are identical twins (who are, for all intents and purposes, genetic clones of each other) and there are non-identical twins (who share as much genetic →

→ material as you would with your own siblings or parents – 50 per cent). If you study a large enough number of twin pairs, let's say thousands, then you can examine any given human trait or behaviour and compare the variation if 100 per cent of genes are shared versus 50 per cent.

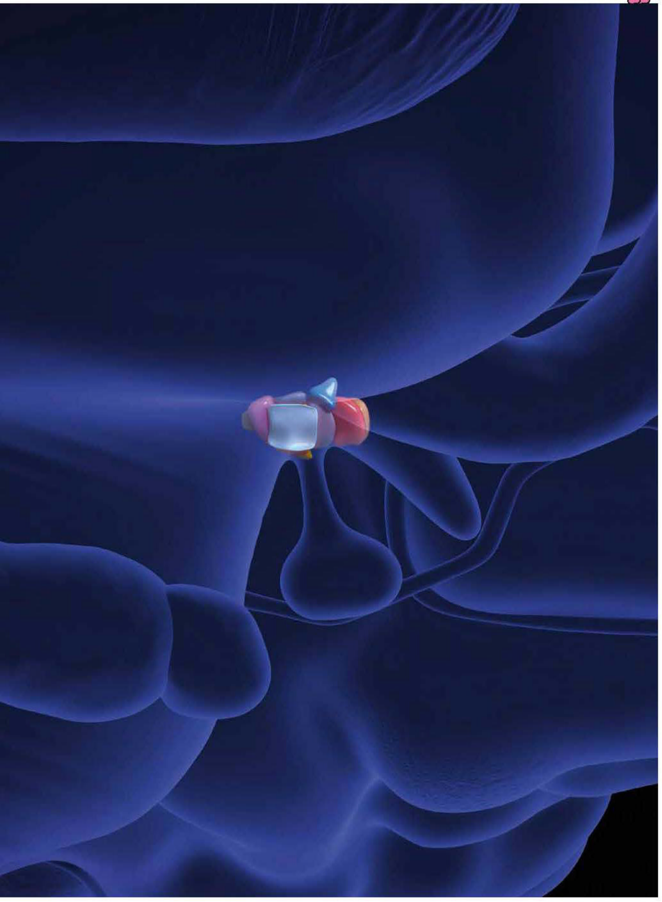
From these studies, we can see that the heritability of body weight is between 40 and 70 per cent. For some perspective, the heritability of height, which no one would doubt has a genetic contribution, is around 85 per cent. Body weight isn't that far away from that.

CONTROLLING YOUR APPETITE

What we in the field now know, is that the genetics of body weight is, by definition, the genetics of how our brain influences our drive to eat. This is otherwise referred to as our appetite.

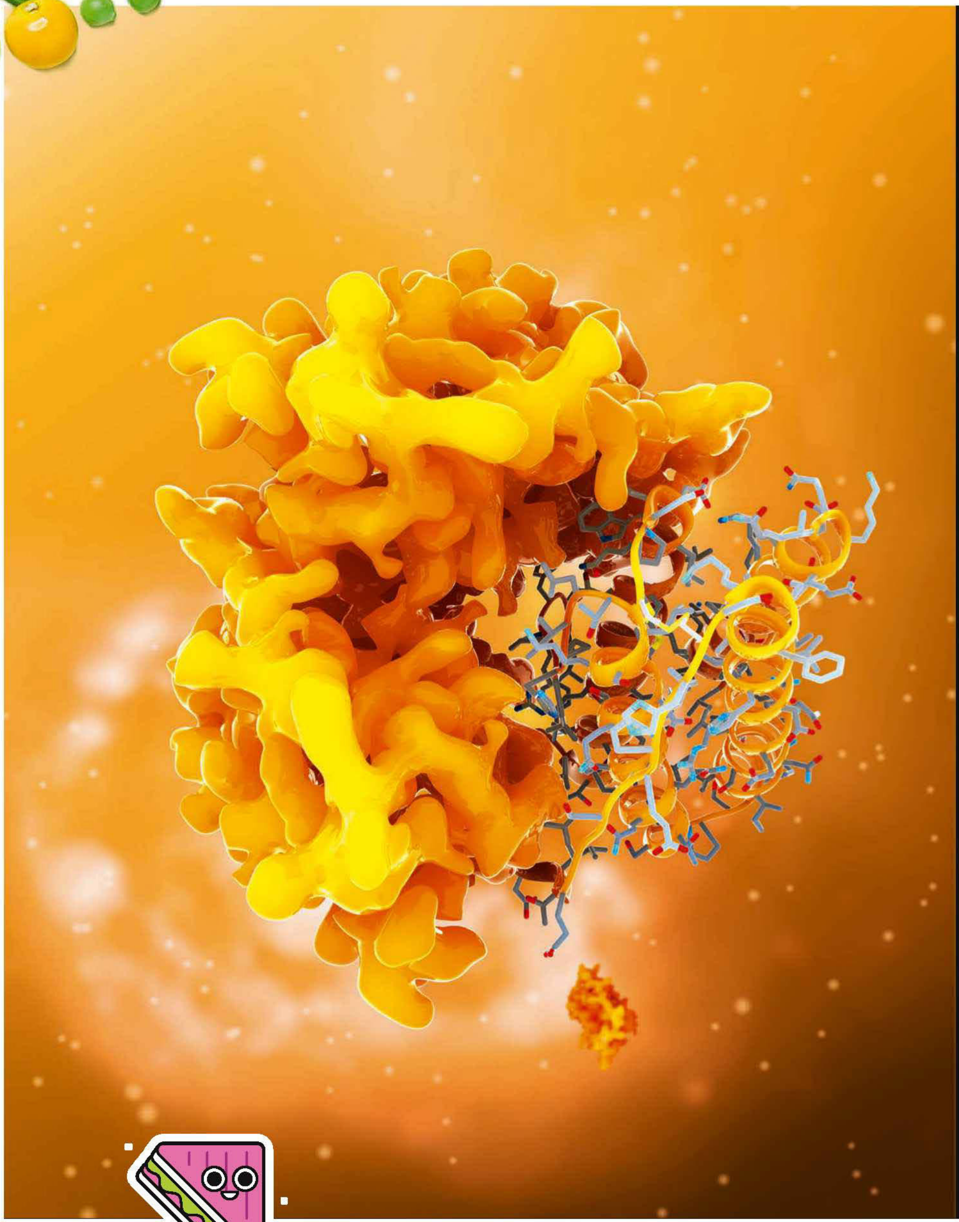
When it comes to food, appetite regulation is surprisingly complex, since it houses three broad concepts: hunger, fullness and reward. Each of these is regulated by different parts of the brain. Hunger is regulated by a region called the hypothalamus at the base of the middle of the brain. Fullness – a feeling ranging from being comfortably content to 'OMG, I feel like puking' – is mediated largely by the hindbrain, the region close to where your head connects to your neck. Finally, the rewarding feeling triggered by eating is regulated by a dispersed higher brain area, loosely termed the 'hedonic region.'

Although geographically distinct, these regions aren't mutually exclusive of each other; they're interconnected and speak to each other. I find it useful to conceptualise hunger, fullness and reward as three points of a triangle, with appetite sitting in the middle (accepting that this two-dimensional visualisation is a vast over-simplification).



> "APPETITE REGULATION IS SURPRISINGLY COMPLEX, SINCE IT HOUSES THREE BROAD CONCEPTS: HUNGER, FULLNESS AND REWARD"

SCIENCE PHOTO LIBRARY X2, GETTY IMAGES, ILLUSTRATION: PATSWERK



Whenever you tug at one of the points, you're going to affect the other two and so alter the overall shape of the triangle. A multitude of internal biological and external environmental signals influence the shape of this triangle, thus changing our overall appetitive drive.

Starting with internal signals, your brain needs two pieces of info about your status to influence appetite. First, it needs to know how much fat you're carrying (as your long-term energy source, it's directly related to how long you would last in the wild without food). Second, your brain needs to know how much you're eating and have just eaten, which it gets from short-term energy signals coming from your gut. Both these long- and short-term signals are hormonal, meaning they're secreted into your bloodstream, where they eventually signal to the brain.

GET A SENSE OF YOUR FAT

With appetite regulation, the key fat-sensing circuit is the so-called 'leptin-melanocortin pathway.' Leptin is a hormone produced by fat, whose circulating concentrations are directly related to fat mass. In short, more fat, more leptin. This is the best-characterised and, as far as we know, the most critical circuit in the brain that senses fat and regulates appetite.

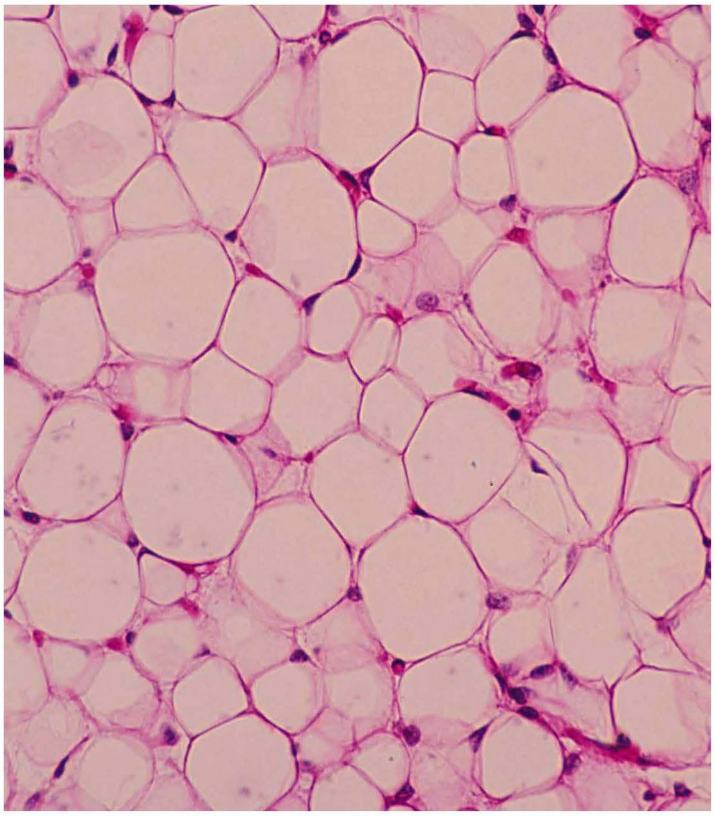
In fact, genetic mutations at every stage of this pathway result in increased food motivation and obesity. We have, for example, found that around 0.3 per cent of the population carry mutations in the MC4R gene, which plays a part in this system. If you apply this figure to the UK population of nearly 68 million, we're talking about more than 200,000 people. People who carry this MC4R mutation are, on average, 18kg (40lbs) heavier at 18 years of age.

This isn't a human-specific phenomenon either; naturally occurring mutations in the melanocortin pathway have been identified in a wide range of different species. We've found that 20–25 per cent of labrador retrievers, which →

ABOVE LEFT Our drive to consume food comes down to genetics, even if other factors play a part

ABOVE A model of the leptin hormone, which builds and circulates proportionately with the amount of body fat

FAR LEFT A function of the hypothalamus is to regulate hunger, but that's only one part of appetite regulation



Humans who carry genetic variations in this key pathway, whether severe or subtle, essentially have a less sensitive fat sensor. Put simply, their brains think there's less fat on board than they actually carry. How much less is sensed by the brain depends on the severity of the mutation. This increases the feeling of hunger, which drives them to eat more.

There's now a drug that targets this system, called setmelanotide (from Rhythm Pharmaceuticals), which targets the MC4R to reduce hunger. It has been approved for rare genetic causes of obesity, including POMC deficiency, and is currently being trialled for those individuals with MC4R deficiency.

REPERTOIRE OF HORMONES

Next, we come to gut hormones. Every time we take a mouthful of food – from the moment we begin chewing until the moment it emerges out the other end – an entire repertoire of hormones is released along the way that signals to the brain not only how many calories are in the meal, but its 'macronutrient content.' That is how much protein, fat and carbohydrates are present. Crucially, of the 20 gut hormones that we know exist, 18 of them make us feel fuller.

Broadly speaking, food that takes longer to digest travels further down the gut, resulting in a shift in the

GETTY IMAGES X2, SCIENCE PHOTO LIBRARY, ILLUSTRATION: PATSWERK

→ are known to be more food-motivated than other dog breeds, carry a mutation that results in a greater appetitive drive and increased body weight. Also, certain breeds of pigs have been shown to carry MC4R mutations associated with fatness, growth and food intake traits. These mutations even contribute to the adaptation and survival of blind Mexican cavefish to the nutrient-poor conditions of their ecosystem.

Still, for genetic disruption of the leptin-melanocortin pathway to result in severe obesity, remains a rare occurrence. The 'common' obesity that currently blights us is more likely to be 'polygenic' in origin ('poly' meaning 'many', so 'many-genes'; this is in contrast to 'monogenic', or single-gene). This will come with many subtle genetic variants, each instance of itself with an almost imperceptible effect, but when pulled together producing a cumulative measurable consequence.

There are now more than 1,000 genes that have been found to influence body mass index (BMI). Among these are genes for many components of the melanocortin pathway, including POMC and MC4R, which regulate food intake.

ABOVE The FTO gene is widely expressed in the hypothalamus, the area of the brain that controls our appetite. People with more copies of the FTO gene tend to weigh more on average

ABOVE A close-up of the adipose cells that make up your body's fat tissue

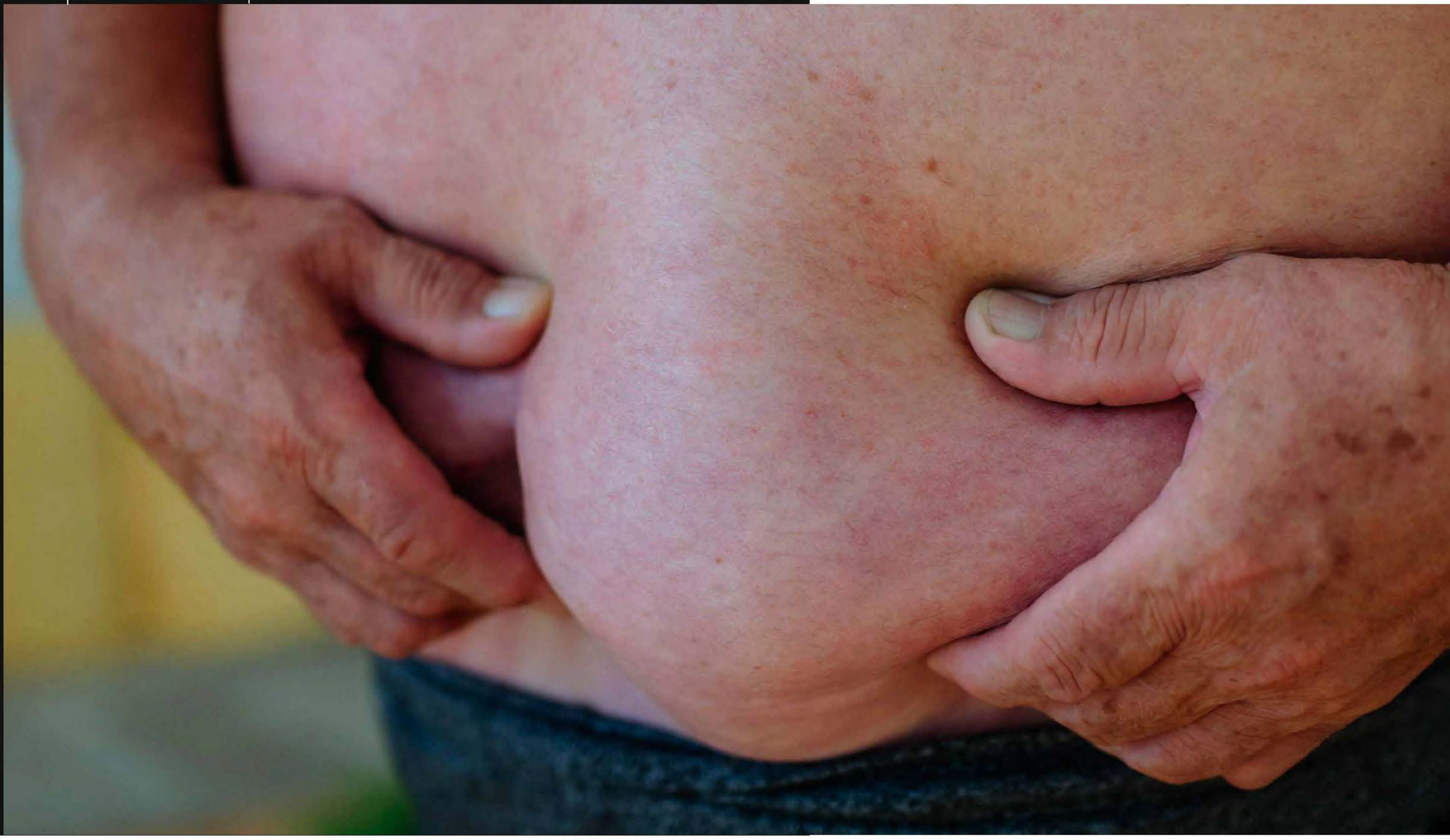
LEFT Environmental signals, such as the scent of freshly baked bread, can override the hormonal signals that let you know when you're full

> "THERE ARE NOW MORE THAN 1,000 GENES THAT HAVE BEEN FOUND TO INFLUENCE BMI"

gut hormone repertoire, which increases fullness. This is true, for example, for foods that are higher in protein content and is one of the reasons why diets such as Atkins or Keto work – they tend to make you feel fuller, meaning you eat less and so lose weight.

One of the key gut hormones that increases substantially after a meal, and is particularly sensitive to protein, is GLP-1. The whole new class of anti-obesity drugs taking the world by storm, exemplified by the likes of Ozempic and Wegovy (both containing semaglutide), centre around modified versions of this hormone. A main issue with native GLP-1 is its vanishingly short half-life of two minutes, as it's rapidly degraded. These drugs' superpower is the menagerie of chemical decorations that have been deployed to extend their life, so that current iterations have been approved as weekly injections, while others in the pipeline work as monthly injections.

As many of you would have undoubtedly experienced, when you go on a diet, you get hungry, making it difficult to sustain in the long term. What these new drugs do is →



→ make you feel full. This means that while still on the drugs, you're able to keep the weight off without the feeling of increased hunger.

SIGNS IN THE ENVIRONMENT

As complicated as our internal nutritional signals and their regulation are, they're dwarfed in complexity by an almost infinite array of environmental signals. Most of these aren't under our control, yet play a crucial role in influencing our appetite.

There are the aromas, sights and sounds of the foods themselves, such as the smells of sizzling bacon, freshly baked bread or brewed coffee; and then there are learnt cues that our primitive brains use to predict the presence of certain types of foods. Like seeing a big yellow M on a roadside sign, for instance. These signals can override any internal hormonal signals.

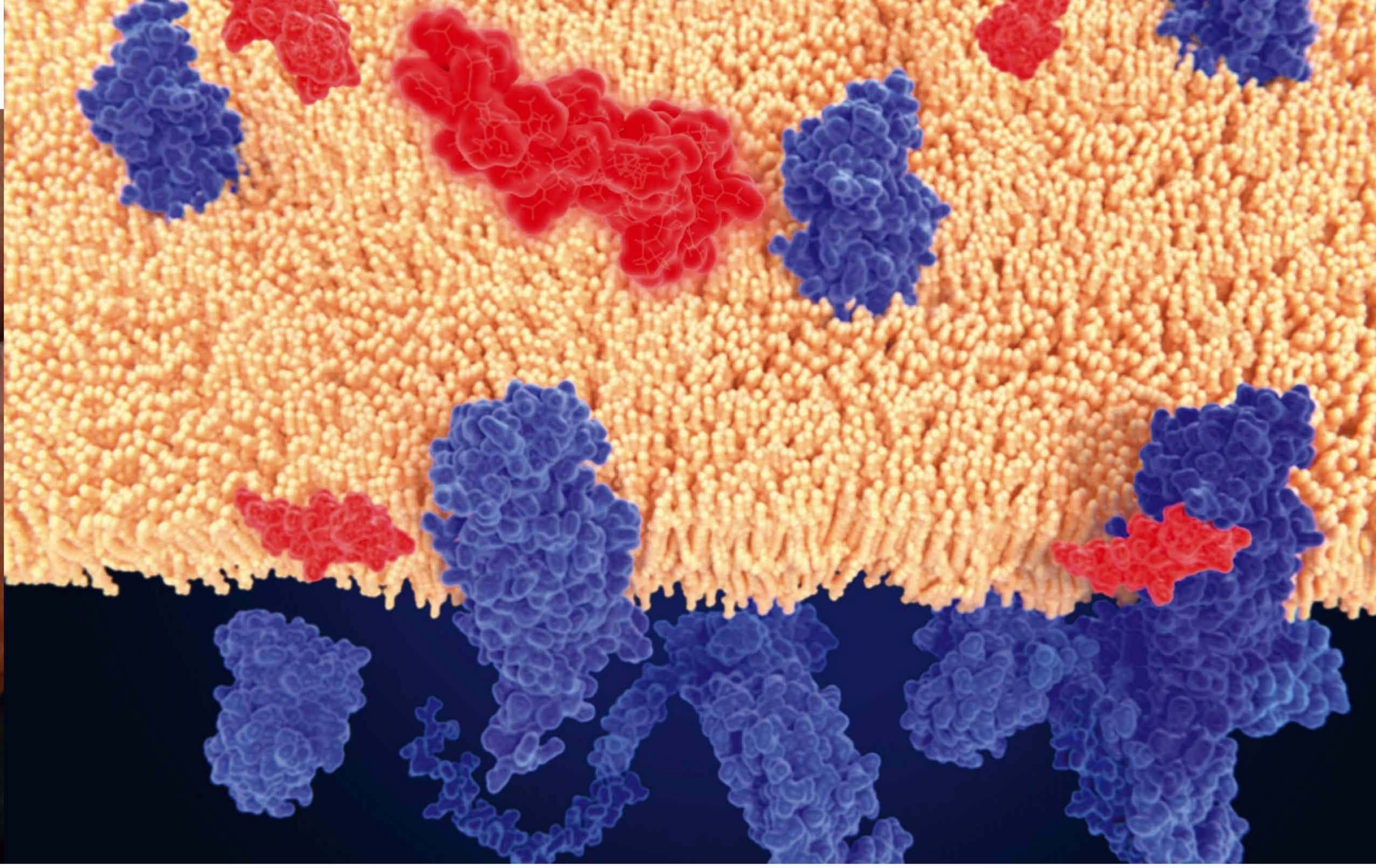
But the biggest environmental influence of appetitive behaviour is socioeconomic status. In the UK, those in the bottom 20 per cent of the socioeconomic strata are almost twice as likely to end up living with obesity (where the prevalence of obesity is 36 per cent) as those in the top 20 per cent (where the prevalence is 20 per cent).

> "IN THE UK, THOSE IN THE BOTTOM 20% OF THE SOCIOECONOMIC STRATA ARE ALMOST TWICE AS LIKELY TO LIVE WITH OBESITY AS THOSE IN THE TOP 20%"

In fact, in a study of twins in the Gemini cohort – a population-based prospective cohort of twins born in England and Wales between March and December 2007 – the heritability of BMI was demonstrated to be higher among those living in a lower socioeconomic and more obesogenic environment (86 per cent), as compared to those in a higher socioeconomic and less obesogenic environment (39 per cent).

The difference between rich and poor isn't genetic, but an accident of birth. What the study tells us is that if an individual is genetically susceptible to obesity, then being exposed to a less healthy food environment maximises their genetic burden, while conversely a

ALAMY, GETTY IMAGES, ILLUSTRATION: PATSWERK



healthier environment more than halves the risk. This illustrates why there is a range for the heritability of BMI of 40–70 per cent.

PRIMITIVE INSTINCTS

Ultimately, appetite is an integrated system where the triangle of hunger, fullness and reward are interconnected, while pushed and pulled by internal biological and external environmental signals. An example of this is when you're really hungry, and simple foods taste more delicious than normal; a bit of bread, cheese or some rice is enough to trigger the reward circuits. The fuller you are, the pickier you become, until, for example, only chocolate will do. This is the explanation for the 'dessert stomach' phenomenon.

Then we have the example of the role of socioeconomic status. Basically, if your genetic hand of cards means you find it more difficult to say 'no' to food, then there are clear advantages to being in a situation where you're not forced to make the decision in the first place. Compare, say, living in a leafy Cambridgeshire village, like me, versus an inner city area adjacent to a multitude of cheap and unhealthy food options.

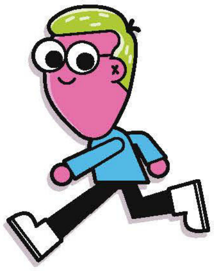
In some quarters, there remains a strongly held belief that we're in full control of our eating behaviour; that the environment is responsible for our shape and size, while our genes have minimal, if any, effect. It's crucial to remember, however, that the drive to consume food is one of the most primitive of instincts. It has been shaped by millions of years of evolution and provided living creatures with powerful and redundant mechanisms to adapt and respond to times of nutrient scarcity.

I would argue that to be overweight in today's environment is indeed the natural (highly evolved even) response. The main issue is that this environment – where energy-dense foods and stimulatory food cues are ubiquitous, while lifestyles have concurrently changed – is in dissonance with the millennia of austere surroundings to which we have adapted. This has pushed obesity to become the serious problem it is now.

I'm fully aware that without this obesogenic environment, most of us wouldn't be overweight or obese. But to deny the central role that our genes have played in our response to this environment, however, is unhelpful as we strive to tackle one of the greatest public health challenges of the 21st century. **SF**

ABOVE LEFT Humans evolved to adapt to times when there wasn't much to eat, but in an obesogenic environment, those traits are exacerbating the obesity problem

ABOVE An illustration of GLP-1 hormones (in blue) released after eating, and semaglutide (red), which is forming the basis of many anti-obesity drugs



---

by **PROF GILES YEO** *(@GilesYeo)*
Giles is a geneticist at the University of Cambridge, whose work focuses on food intake, genetics and obesity.

THE BIG QUESTION

WHAT IS GRAVITY 'MADE OF'?

If particles are what carry the force of gravity, those particles should be detectable… in theory

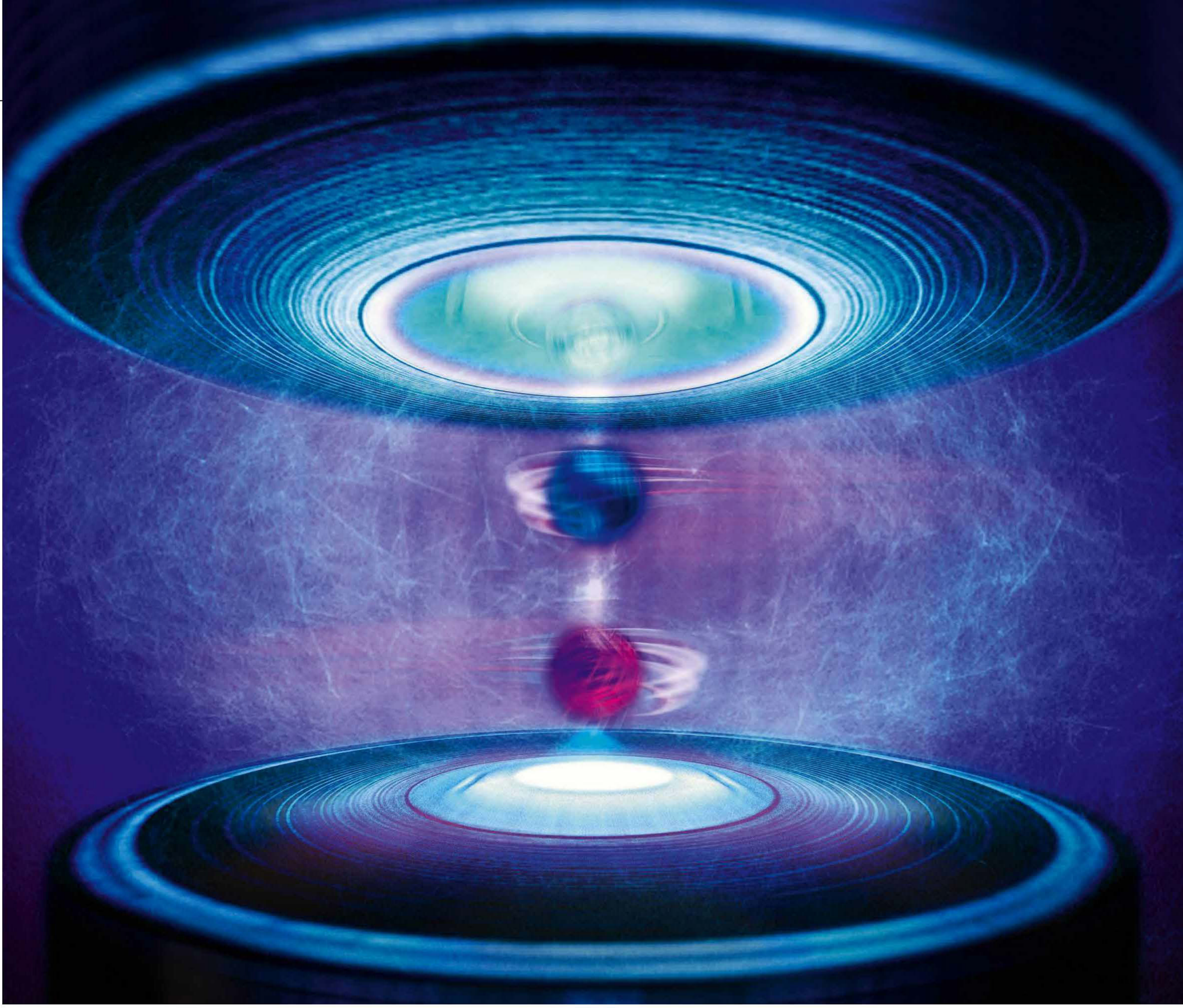
by MARCUS CHOWN

Gravity is one of the four fundamental forces that glue the stuff of the Universe together. Because the three non-gravitational forces (electromagnetism, and the weak and strong nuclear forces) have been successfully described as arising from the exchange of force-carrying subatomic particles, theorists suspect a similar 'quantum' description also exists for gravity.

The force carrier of the electromagnetic force that binds together the atoms in your body is the photon. For the weak nuclear force, which operates within the cores, or nuclei, of atoms, there are three force carriers: the W^-, W^+ and Z^0 bosons; and, for the strong nuclear force, eight kinds of gluons. The hypothetical force carrier of gravity has been christened the 'graviton.' The properties of the graviton aren't hard to deduce. In quantum theory, the greater the energy required to conjure a force-carrying particle out of the vacuum, the quicker that energy must be paid back. This means a heavy particle like a W^+ boson, whose creation requires a lot of energy, exists for a short time, during which it can barely travel at all, explaining the weak force's tiny range. In contrast, the range of gravity is infinite, which implies no energy is required to make a graviton. It must, therefore, have zero mass.

> **"Just because we don't have a quantum theory of gravity, doesn't mean gravitons don't exist"**

Another property that can be deduced for the graviton is its 'spin.' In the quantum world, spin is connected to rotations of space. The fundamental building blocks of matter – quarks and leptons – have spin-½, which means they don't behave the same after being rotated through 360°, but only after 720°. The force carriers of the three non-gravitational forces all have spin-1, which means they behave the same after a rotation of 360°. The graviton, however, must have spin-2, because only a spin-2 particle interacts with *all* matter, a



Quantum particles possess a property known as spin. The graviton must have spin-2, as only a spin-2 particle interacts with all matter

SCIENCE PHOTO LIBRARY

fundamental feature of 'universal' gravity. It takes a rotation of 180° to bring it back to the same state.

Of course, it's possible there's no description of gravity in terms of the exchange of gravitons. Most physicists, however, believe that gravity can be quantised. The problem is the mathematical techniques used to quantise the other forces fail in the case of gravity. The only framework that holds any hope is string theory. Here, the fundamental particles are envisaged not as point-like, but as different vibrations of strings of mass-energy.

One of the selling points of string theory is that one such vibrating string has the properties of a graviton. Unfortunately, the theory has serious problems. Not only are the strings postulated to be much smaller than an atom (and therefore undetectable), but in order to reproduce all the fundamental forces, the strings must vibrate in 10 dimensions of space-time – six more than we observe. Even more seriously, the mathematics of string theory is so complex that it's yet to make any testable predictions.

THE DIFFICULTY OF DETECTION

But, just because we don't have a quantum theory of gravity, doesn't mean gravitons don't exist. We know that a light wave is composed of photons travelling together. And, by analogy, we suspect that a gravitational wave – a ripple in the fabric of space-time, first detected in 2015 coming from merging black holes – should be made of gravitons travelling together. We can dim a light source until a sensitive detector registers the rat-a-tat-tat of individual photons. But detecting individual gravitons is formidably hard. The reason is that gravity is extremely weak – 10,000 billion, billion, billion, billion times feebler than the electromagnetic force – and, in quantum theory, weakness is synonymous with infrequent interaction with matter.

Gravitons, in other words, are hardly ever stopped by atoms, making them phenomenally difficult to detect.

To convey some idea of the elusiveness of gravitons, think of neutrinos. These are created by sunlight-generating nuclear reactions in the Sun and about a trillion pass through you every second without being stopped. Gravitons interact with matter 1,000 million, trillion times less frequently than neutrinos. We can increase the chances of a neutrino →

→ being stopped by a particle by putting a lot of them in its way – using a detector with a large mass. This would also be the strategy for detecting a graviton. However, because of its phenomenally weak interaction with matter, we're talking about a detector that utterly dwarfs a neutrino detector.

The biggest neutrino detector is IceCube at the South Pole, which consists of one cubic kilometre of Antarctic ice. To have any chance of detecting a graviton, however, a detector would need to have the mass of Jupiter (any bigger and a detector would shrink under its own gravity and become a brown dwarf – a hot failed star).

In 2008, Tony Rothman of Princeton University and Stephen Boughn of Haverford College considered the possibility of using a Jupiter-mass detector. The most powerful source of gravitons considered was Hawking radiation, from evaporating black holes, about one per cent of which should be in the form of the particles. Hawking radiation turns out to be negligible for stellar-mass black holes and significant only for small black holes.

The best sources of gravitons are therefore hypothetical mini black holes created in the extreme and violent conditions of the Big Bang and which have survived until the present day.

Rothman and Boughn made the highly optimistic assumption that, in the Milky Way, as much mass is tied up in mini black holes as in stars, and that the average distance of all these black holes is the distance from Earth to the centre of the galaxy. They concluded that a Jupiter-mass detector would take more than the lifetime of the Universe to register a single graviton.

STEPS IN THE RIGHT DIRECTION

Such a detector would look for electrons ejected from atoms by gravitons, the gravitational analogue of the 'photoelectric effect' in which an electron is kicked out of an atom by a photon. A huge problem, however, would be distinguishing such electrons from those created by neutrinos. This could only be achieved with a light-years-thick layer of shielding around the detector, which is unfeasible. "I'd bet my house that nobody in this Universe will ever detect a graviton," says Rothman. "It may be the graviton should be considered a metaphysical, rather than a physical, entity."

Recently, however, hope has grown that we may be able to explore the properties of gravitons experimentally. Previously, in the laboratory, researchers have constructed liquid analogues of black holes, in which they have searched for hypothetical Hawking radiation. And now, an international team of scientists, led by Prof Jiehui Liang of Nanjing University in China, claims to have found an analogue of a spin-2 particle in a 'fractional quantum Hall effect' liquid.

In this ultra-cold system, confined to two dimensions by a strong magnetic field, electrons behave in a collective manner, like a large flock of starlings during a murmuration. Crucially, the murmuration has the property of a spin-2 particle.

Of course, this isn't a real graviton. Nevertheless, it raises the possibility of furthering our understanding of these particles. And such an understanding may help physicists break through the roadblock that's currently stymying their attempts to find the elusive quantum theory of gravity that will unify the fundamental forces into a single theory of everything. **SF**

> **"The best sources of gravitons are therefore hypothetical mini black holes created in the extreme and violent conditions of the Big Bang"**

by **MARCUS CHOWN** *(@marcuschown)*

Marcus is an award-winning writer and formerly a radio astronomer at the California Institute of Technology. His latest book is A Crack in Everything *(Head of Zeus, £20).*

GETTY IMAGES

Starlings in a murmuration are thought to behave in a manner analogous to a spin-2 particle

The Royal Institution
Science Lives Here

Explore Royal Institution science and be inspired

@Ri_Science @RoyalInstitution

- Science talks
- Free museum
- Digital content
- Workshops and courses

Get involved today

The Ri is the place for science enthusiasts! See what's on and discover great science content. Also explore Ri Membership to get exclusive discounts, enjoy free events and have a chance to enter the CHRISTMAS LECTURES ballot - exclusive for Ri Members!

rigb.org

BBC COUNTRYFILE MAGAZINE
The Plodcast

DON'T JUST READ *BBC COUNTRYFILE MAGAZINE*... LISTEN TO IT, TOO

Your chance for a weekly adventure in nature and the countryside with the *BBC Countryfile Magazine* team

You can find the Plodcast on Apple Podcasts, Google, Spotify, Acast and all good podcast providers.
You can also visit our website for more detail: **countryfile.com/podcast**

Q&A

YOUR QUESTIONS ANSWERED

DR NISH MANEK
Health

DR ALASTAIR GUNN
Astrophysics

SWEET DREAMS

ANDREW TAYLOR, VIA EMAIL

HOW CLOSE ARE WE TO BEING ABLE TO RECORD OUR DREAMS?

Artificial intelligence (AI) that works with mind-reading machines is the type of technology that we'll need to reproduce what we experience in our dreams. A well-publicised Japanese research study demonstrated the beginnings of the method in 2023: researchers recorded the brain activity of sleeping participants using functional magnetic resonance imaging (fMRI) scanners and then used machine learning to classify perceived objects, such as a key, a person or a chair from the activity. However, the study was focused on sleep onset: the first two stages of sleep during which we experience visual imagery (hallucinations) and didn't look at dreams at all. They chose this approach so the participants could wake up and quickly describe what they saw.

To reproduce our dreams, we need a lot of detailed fMRI data from dreaming volunteers with which to train a large AI. The volunteers need to be very good at remembering their dreams in a lot of detail so that we'll know how accurate any prediction may be. This is likely to be the most difficult part about recording dreams and it's unclear how this kind of data can be generated reliably.

But we already have a head start in a related area: there have been research studies that have produced huge datasets of fMRI brain activity while conscious participants watch thousands of videos, listen to spoken-word recordings and read text. Using AIs trained on these datasets we can already predict what a waking person may be watching or reading.

If we assume that, in a few years, we'll have sufficient data to make such an AI and

LUIS VILLAZON
Everyday science

DR DEAN BURNETT
Neuroscience

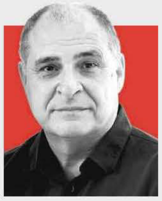
DR HELEN PILCHER
Biology

HAYLEY BENNETT
Wellness

DR CHRISTIAN JARRETT
Psychology

PROF PETER BENTLEY
Future tech

DR EMMA DAVIES
Food science



PETE LAWRENCE
Astronomy

> **"IF WE HAVE SUFFICIENT DATA AND PORTABLE FMRI MACHINES THAT ARE QUIET ENOUGH, THEN WE ALREADY HAVE THE METHODS NEEDED TO SHOW THE RESULTS"**

we have portable fMRI machines that are quiet enough to let you sleep while they scan your dreams, then we already have the methods needed to show the results.

Generative AIs, such as Sora from OpenAI and Lumiere from Google DeepMind, can make very dream-like video sequences already. Use the dream-analysing AI to provide a clear textual description for the generative AI and you'll get a video illustrating the likely dream sequence from that person.

A word of warning, though. These AIs are not really reading minds; they're just matching patterns of brain activity to likely images they've seen before. And the generative AI will have no idea if its video resembles your dream – it'll simply string the images together, perhaps with some rudimentary story. So, while the result will look spookily dream-like and may contain many of the same elements as the original dream, it won't be an accurate reproduction – any more than the Tom Hanks movie *Cast Away* resembles the true story of José Salvador Alvarenga, the fisherman who spent 14 months stranded on a fishing boat adrift in the Pacific.

AI is amazing, clever and spooky. It's just not always very accurate when it comes to our brains. ***PB***

GETTY IMAGES X2 ILLUSTRATION: GHELEYNE BASTIAEN

AIMEE BARRETT, VIA EMAIL

HOW CAN YOU TELL IF A SPIDER IS DANGEROUS?

Broadly speaking, spiders aren't dangerous. There are 45,000 species of spider worldwide, but only around 30 can inflict a serious bite. So, you can take any random spider and say with 99.9 per cent confidence that it's not dangerous. Even in Australia, the last recorded spider bite fatality was in 2018 and the one before that was in 1979, although this is partly due to effective antivenom treatment.

In the UK, only 12 of the 650 native species have fangs that can pierce human skin. None are worse than a wasp sting, but there isn't a single identifying feature to tell them apart from harmless species. ***LV***

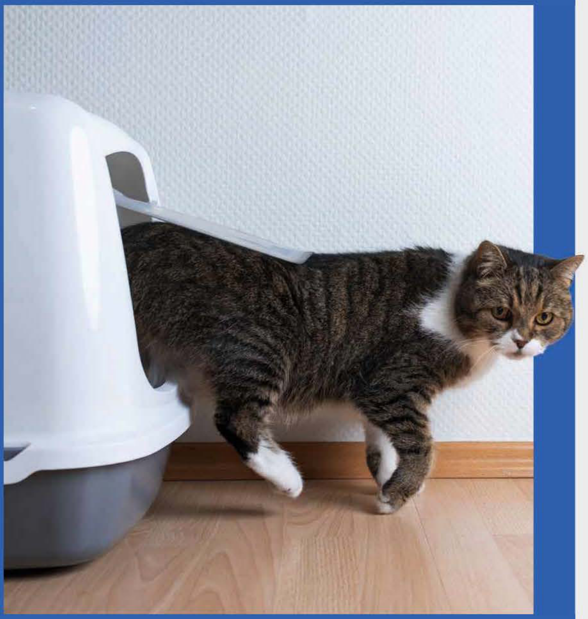
BEN CATCHPOLE, CROYDON

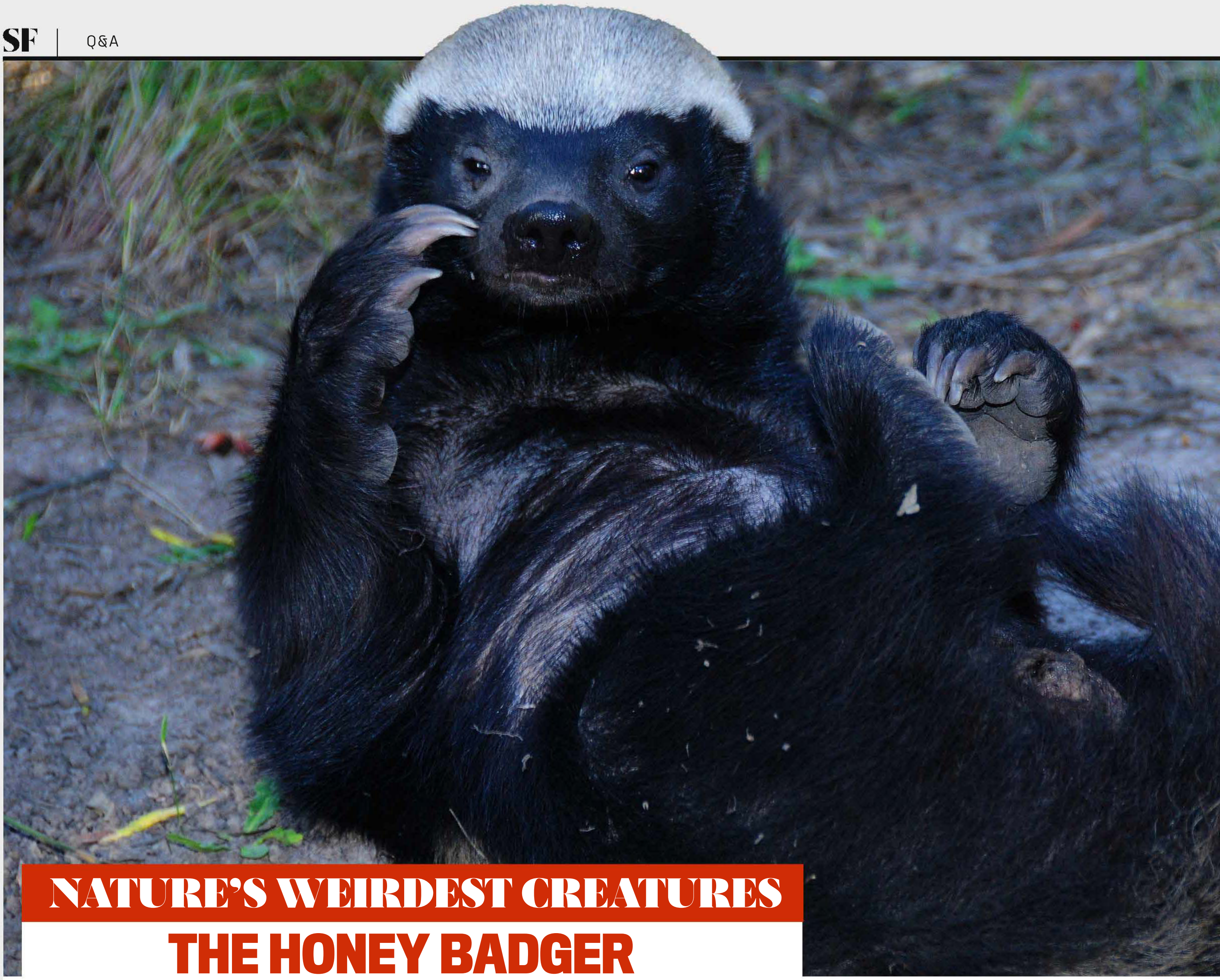
WHY DO CATS PILE UP IMAGINARY LITTER OUTSIDE THEIR LITTER BOX?

It's the age-old mystery: who knows why cats do anything? Cats are as resistant to logic as bullets are to Kevlar. The most likely explanation, however, is that this is a relic behaviour from their evolutionary past.

Wild cats, from which domestic cats are descended, have an innate instinct to bury their waste. This helps to prevent disease and infection, and avoids leaving blatant scent markers that predators and rival cats could use to locate them.

So, either cats have retained the genetic legacy that prompts this behaviour, or they simply enjoy the art of mime. You choose. ***HP***





NATURE'S WEIRDEST CREATURES

THE HONEY BADGER

It's definitely not a 'honey' and it's not much of a badger either. While it may belong to the same family of mammals as 'regular' badgers, the honey badger doesn't really look like one. Anatomically, it's much closer to a weasel or a polecat.

This feisty, cocksure carnivore is found across much of Africa, Southwest Asia and India, where it's renowned as one of nature's badasses. Famed for their strength, tenacity and toughness, honey badgers will pick a fight with seemingly any animal, of any size, and win, much of the time. They actively attack scorpions, pythons and venomous snakes. When threatened, they'll scrap with and see off large predators such as leopards, lions and hyenas. They'll also go for horses, cattle and Cape buffalo, if the animals mess with their burrows.

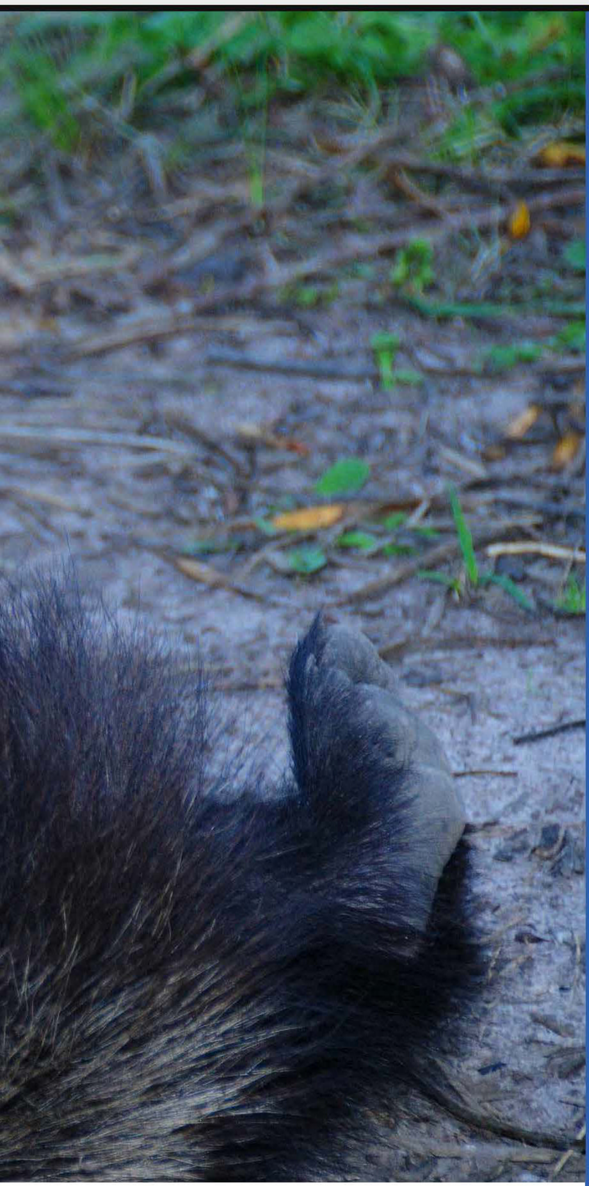
This is particularly impressive for an animal that's not much taller than a toaster. Adults are about a metre (3ft) long, with a broad white stripe that runs from head to tail, but they're thickset and chunky. They have teeth that can crush bone and jaws that can split tortoise shells.

With long, powerful foreclaws you could say the animal resembles Freddy Krueger, but the honey badger wouldn't care – it literally has some of the thickest skin in the animal kingdom. The loose skin on the ruff of its neck is 6mm (about 1/4in) deep, which helps it to thrash, twist and squirm its way out of trouble, should it find itself in the grasp of a predator's jaws. It also enables the animal to shrug off bee stings and porcupine quills, which rarely pierce the honey badger's skin.

All in all, natural selection seems to have sculpted an animal fine-tuned for fighting and self-defence. The honey badger also has mutations in a key gene which make it immune to the bites of venomous snakes, and a reversible anal pouch which it uses to eject a foul-smelling liquid that can be detected up to 40m (130ft) away. The scent, which has been described as 'suffocating', is used to mark territory, deter predators and calm the bees inside the hives that it raids, which brings us back to its name.

According to folklore, honey badgers are guided to beehives by birds called honeyguides. The badgers break in and eat the larvae. Then the birds get to eat the exposed beeswax. *This* is supposedly what gives the badger its name, but sceptics point out that it's unlikely because honey badgers are primarily active at night, whereas honeyguides fly by day.

A 2023 study countered this view, however. Researchers from the University of Cambridge interviewed around 400 human honey-hunters from across Africa.



"ACCORDING TO FOLKLORE, HONEY BADGERS ARE GUIDED TO BEEHIVES BY BIRDS"

While many had never witnessed the two species interacting, around 60 per cent of honey-hunters interviewed from the Hadzabe tribe in Tanzania had. Here, at least, it seems as if badger and bird really do cooperate to get honey and beeswax from hives. So, maybe the honey badger does deserve its name after all. ***HP***

GETTY IMAGES X2

NATASHA READ, LINCOLN

WHY DO I GET SO BLOATED?

Bloating, that uncomfortable feeling of fullness and tightness in your abdomen, is common. Your stomach might seem fuller than normal, tight and might make strange noises. It might also feel like you need to pass more wind. While bloating is often harmless, it can be a nuisance.

Bloating has a variety of causes, ranging from dietary choices to medical conditions. One common culprit is excess gas in the digestive tract. When you eat or drink, you swallow air along with your food and beverages. Additionally, certain foods and drinks – think fizzy drinks, beans, broccoli, sprouts and cabbage – can produce gas during digestion. This gas can accumulate in your digestive system, leading to bloating. Some people find specific things like chewing gum, sweeteners, alcohol, caffeine and protein supplements can make bloating worse.

Digestive issues, such as constipation and irritable bowel syndrome (IBS), can also contribute to bloating. When stool becomes trapped in the colon, it can cause distention and discomfort. Similarly, people suffering from IBS may experience bloating along with abdominal pain, diarrhoea or constipation.

Keeping these causes in mind, there are some things you can do to address bloating. The first step is to try to identify and avoid trigger foods that commonly cause bloating. Keep a food diary to track your symptoms and pinpoint any patterns between your diet and bloating episodes. You could then try eliminating these trigger foods one at a time to see if it makes a difference.

When it comes to a diet that can help prevent bloating, opt for whole, unprocessed foods that are rich in fibre, such as fruits, vegetables, whole grains and legumes. Additionally, fermented foods like yoghurt and kefir contain probiotics (beneficial bacteria) that can aid digestion and potentially reduce gas production. Certain herbs and spices, such as ginger, peppermint and fennel, have traditionally been used to alleviate bloating and improve digestion. Some people find linseeds and oats helpful, too.

As well as dietary modifications, there are several lifestyle changes you can try. Eating smaller, more frequent meals can help, as well as chewing your food slowly and thoroughly to reduce the amount of air you swallow. Drinking plenty of water can help prevent dehydration and promote regular bowel movements, which may alleviate bloating. Regular physical activity can also help by stimulating digestion and reducing water retention.

If the bloating persists, you might want to see a doctor, especially if it's associated with other symptoms. Very rarely, bloating can be a sign of ovarian cancer, particularly for women over 50. ***NM***

WILL STEADMAN, CHESTER

WHAT IS A NUCLEAR BATTERY AND HOW DOES IT WORK?

The nuclear energy source that powers the Perseverance rover on Mars is a radioisotope thermoelectric generator, or RTG. This uses 5kg (11lbs) of plutonium dioxide to generate electricity by a process known as the 'Seebeck effect.'

The RTG on board Perseverance originally produced about 110W of electricity, declining by a few per cent each year, as the plutonium gradually decays. RTGs are a great way to power distant space probes, but plutonium-238 is highly toxic and definitely not something that you would want in domestic gadgets. Luckily, the batteries recently developed by Chinese manufacturer Betavolt use a completely different process. Some radioactive isotopes decay by beta-emission, which means that they give off electrons. If you sandwich thin layers of such an isotope between layers of semiconductor, you can catch the electrons and turn them into useful electricity.

Betavoltaic batteries based on the rare element promethium were used in some early heart pacemakers in the 1970s, but were phased out in favour of cheaper lithium batteries. The newer Betavolt batteries use the isotope nickel-63 between layers of diamond semiconductor.

The power output is quite small – just 100 *micro* watts compared to around 2.4W for an ordinary AA battery. But the AA battery will be flat after an hour of this output, whereas a Betavolt battery is claimed to be able to deliver a useful voltage for 50 years. That's because nickel-63 decays quite slowly with a half-life of 101 years.

Betavoltaic batteries are pretty safe because electron emission is less damaging to living tissue than alpha particles or gamma rays, and the electrons are easily blocked by the metal of the battery case or even clothes. You would need to break the battery open and swallow it to cause any harm. The radioactive nickel eventually decays to non-radioactive copper. ***LV***

JAMES COOPMAN, VIA EMAIL

SHOULD I USE A FOOTSTOOL WHEN I'M POOPING?

In short, if you have no issues opening your bowels at the moment, you don't especially need a footstool.

If, however, you suffer from constipation, haemorrhoids or pelvic floor disorders, it might be worth trying a footstool. It can sometimes help these conditions by promoting more efficient bowel movements and reducing straining.

We evolved to open our bowels while squatting down, a position that aligns the rectum properly and relaxes the puborectalis muscle, facilitating easier bowel movements. Historically, and in some cultures today, people pass stools in a squatting position. But our modern-day toilets make us do this in a more upright, seated position. In theory, when we sit like this, the puborectalis muscle remains partially contracted, creating a kink in the rectum that can possibly make defecation more difficult.

One study published in the *Journal of Clinical Gastroenterology* in 2019 investigated the effect of posture on defecation. The study found that using a footstool while sitting on the toilet significantly reduced the time needed for defecation and decreased the subjective sensation of straining. But only 52 participants took part in the study and the symptoms are, of course, subjective.

Another study of 28 participants, published in *Digestive Diseases and Sciences* in 2003, found both the time needed for the sensation of satisfactory bowel emptying and the degree of straining in the squatting position, were reduced sharply in all volunteers compared with sitting positions. But, again, it wasn't a big study.

We do often advise footstools for children with constipation and, anecdotally at least, this does seem to help a bit.

Overall, it's unlikely to do any harm, so it might be worth a try if you suffer from any of the conditions mentioned. Do combine it with simple measures to reduce constipation too – such as increasing your fluid and fibre intake. ***NM***

ALAMY, GETTY IMAGES ILLUSTRATIONS: GHELEYNE BASTIAEN, PETE LAWRENCE

ARCHIE FOX, VIA EMAIL

WHAT'S THE BEST COMEBACK TO AN INSULT?

It's often said, "sticks and stones may break my bones, but words can never hurt me." But that's wrong; because criticisms and rejection cause brain activity that's indistinguishable from actual pain. Basically, insults *do* hurt.

Insults are complex concepts that have been studied at length. And it turns out that the impact of an insult depends as much on the *recipient* as it does the supplier. So, when it comes to straightforward insults (ones that lack socio-historical weight), the 'targets' have notable control over the outcomes. And there are many scientifically recognised ways to successfully diffuse insults or reverse their effects.

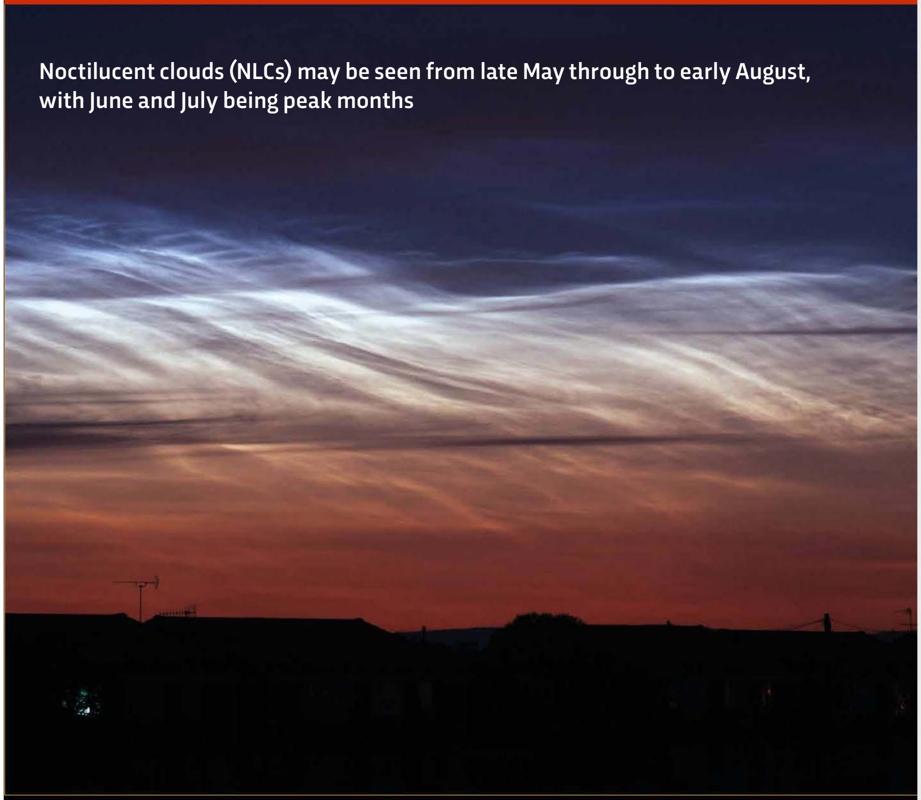
One is ascribing category membership to the insulter; making the insulter seem like the lower status, more easily-ridiculed party. Someone says, "Your haircut looks stupid." You reply, "Okay, calm down grandma." You've put them in the category 'Older, unfashionable, out-of-touch people', which makes them look worse. Especially if they can't possibly be your grandma, because they're a 20-something man.

Others recommend finding a point that the insulter makes about themselves and amplifying it. They say, "I don't understand why [your attractive partner] is with you," you say, "Would you like me to explain it to you? With crayons?" They meant to insult you, but the response turns it into them admitting to being easily baffled.

Then there's co-constructing criticism, where the insult is accepted and built on. It defangs it. They say, "You're fat!" You say, "I should hope so, I've spent enough money to get this way."

There are countless more comebacks, but they all orbit a central theme of not giving the insulter power, of denying them raised status and retaining control of the narrative or exchange. ***DB***

ASTRONOMY FOR BEGINNERS



Noctilucent clouds (NLCs) may be seen from late May through to early August, with June and July being peak months

SUMMER'S NOCTILUCENT CLOUDS

WHEN: JUNE AND JULY

From the UK, June and July are the peak months for spotting noctilucent, or night-shining clouds (NLSs). Although clouds may sound like a strange thing to be looking out for in astronomy, these are related to meteor activity and so have an astronomical link (lingering meteor dust high in the atmosphere provides a footing for ice crystals to form around). With the period of night-time darkness rather short currently, NLCs provide an interesting and relatively easy target to try and spot.

NLCs are ice-sheet clouds that form around 82km (51 miles) up in the mesosphere, roughly seven times higher than regular tropospheric clouds. At such heights, they're still bathed in sunlight when the Sun is below the horizon for us on the ground and, as such, appear to shine in the deep summer twilight.

The good news is that you don't need any special equipment to see them, just your eyes and a flat, unobstructed northern horizon. Typically, they can be seen at low altitudes above the northwest horizon, 90 to 120 minutes after sunset and at a similar time before sunrise, low above the northeast horizon. A big display typically first appears low above the northwest horizon and tracks through north to end low above the northeast horizon – basically keeping position with the Sun as it moves below the horizon.

NLCs tend to have a delicate structure and typically appear light blue-white in colour. They can range from being barely visible to appearing very bright. Sometimes misreported as aurora, a bright NLC display makes a relatively easy photographic target and will be within reach of many modern smartphone cameras, especially those with dedicated night-shooting modes. ***PL***

by PETE LAWRENCE

(@Avertedvision)

Pete is an astronomy expert and presenter on The Sky at Night.

WATCH *THE SKY AT NIGHT* ON BBC FOUR AND BBC IPLAYER

BBC FOUR

ALLY RUNDELL, STROUD

IS IT TRUE THERE ARE GROUND-UP COCKROACHES IN PACKETS OF PRE-GROUND COFFEE?

I can't say for sure that there are no cockroach parts in your ground coffee, but there's no documented evidence of widespread contamination. It's most likely an urban myth. In any case, the insects are packed full of nutrients, including calcium, magnesium and iron.

The US Food and Drug Administration (FDA) permits low levels of natural contaminants, including insect parts, in foods. An FDA handbook also tells manufacturers to 'take action' if, on average, 10 per cent or more of green coffee beans are "insect-infested or insect-damaged." The beans should be easy to spot and removed before coffee roasting.

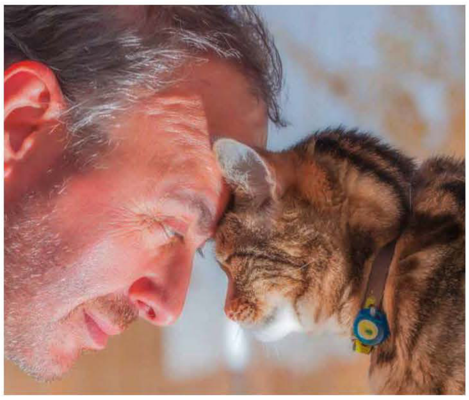
But cockroaches aren't really a problem for coffee growers. They're far more worried about the coffee berry borer beetle (*Hypothenemus hampei*), which causes widespread destruction. The females bore into coffee berries and lay their eggs in the seeds – the beans. When the larvae hatch, they devour the beans. The borer beetle is the only insect that can feed solely on coffee beans without being poisoned by caffeine, thanks to detoxifying bacteria in its guts. An FDA document calmly states that "larvae, pupae, adults and debris consisting of excreta and cast skins may be found in coffee."

Another common pest is the coffee bean weevil, which goes for stored beans in warm, damp regions. The beetles and weevils both cause untold damage inside and on the surface of coffee beans.

An FDA guidance document gives tips for 'reconditioning' infested or damaged beans. Insects outside the beans can simply be sifted out or blown away before the beans are processed, it says.

If you're feeling queasy, the best solution would be to buy whole coffee beans and inspect them before grinding them yourself.

If you're still worried about cockroaches, keep an eye out for them in the warm, moist, dark environment of your coffee machine. As one pest control website says, "if you find a cockroach crawling under or near your coffee maker, chances are there are more of them." ***ED***



GEORGE GRAINGER, TRURO

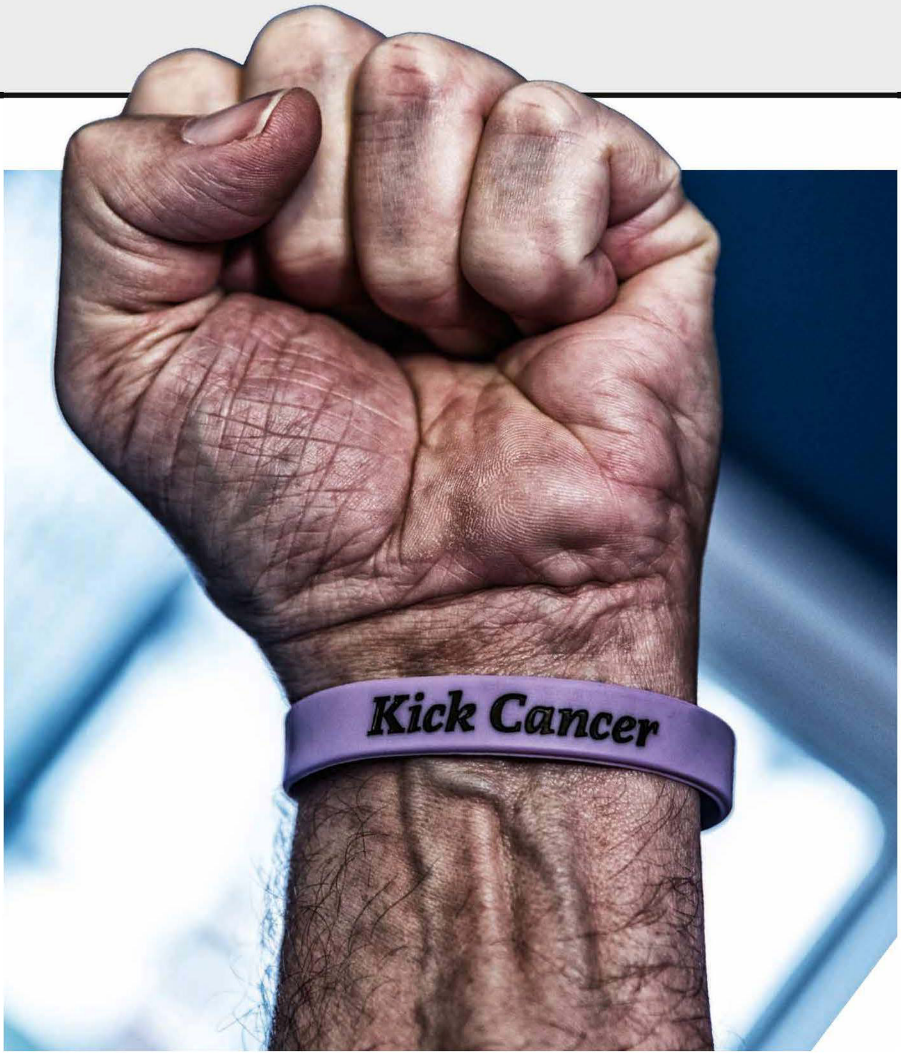
CAN OWNING A PET REALLY SLOW COGNITIVE DECLINE?

Our cognitive abilities – thinking abilities that include memory, language and attention – deteriorate with age and scientists haven't yet found a way to stop this decline. There are things you can do to slow it down, however, and recent scientific studies suggest that having a pet might be one of them.

For instance, in one 2022 study, US researchers tested the cognitive abilities of 1,369 older people who had health insurance policies with Medicare over the course of six years. About half the participants had pets and the researchers found that these people's cognitive abilities declined more gradually than non-pet owners. Within the pet-owning group, those who were longer-term pet owners performed better in tests.

More recently, data from the English Longitudinal Study of Ageing (ELSA), which has followed the ageing process in the over 50s for more than 25 years, has helped scientists further explore the beneficial effects of pets on our brains. Since 2010, the ELSA study has included cognitive tests as well as survey questions about pet ownership, giving researchers data from over 7,945 older people to draw on. According to findings published last year, having a pet did slow cognitive decline on average. However, the results showed that having a pet only really benefited those who lived alone.

Cognitive decline is faster and dementia risk is higher in those who live alone, but it seems pet ownership may be able to rebalance this offset. Of course, there's still lots left to learn about brain health and ageing, but getting a pet may be a straightforward solution to staying sharper into your senior years. ***HB***



SAM EDWARDS, VIA EMAIL

WHAT DOES CANCER BEING IN REMISSION ACTUALLY MEAN?

Cancer in remission usually means that, after some treatment, there are no signs of cancer in the body. Cancer cells might still be there, but they might be too few to find, too few to cause any symptoms, or in an inactive state and not growing. Remission can be complete, meaning there isn't any sign of cancer, or partial, meaning cancer has decreased or stopped growing.

Remission is usually a positive milestone, although not always a guarantee that the cancer won't come back. Regular monitoring during remission is still important, most of the time, to detect any signs of early recurrence. Some cancer survivors may be considered cured after being in remission for a certain number of years. ***NM***

QUESTION OF THE MONTH

COLIN BULLEN, VIA EMAIL

WOULD A PLANET NEED A MOON FOR LIFE TO EVOLVE?

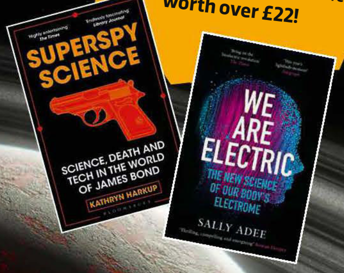
The Moon has a significant influence on Earth. The most noticeable one is the rising and falling of tides (although the Sun is also partly responsible for this). But there are other effects that are less noticeable.

For instance, the Moon influences the tilt of Earth's rotation axis and how fast it wobbles (called 'precession'). Without the Moon, that wobble would be greater and would change much more quickly. The result would be much greater differences between the seasons and much greater variation in climate with latitude over evolutionary timescales.

So, without the Moon, it's probable that life on Earth would have developed and evolved very differently. It may even have not developed at all. But, while a moon may make life more likely, more diverse or more sustainable on a planet, there's no reason to suppose one is required for life to develop and evolve. ***AG***

WINNER

The winner of next issue's *Question of the Month* wins a **pair of popular science paperback books**: *Superspy Science* and *We Are Electric* **worth over £22!**


SUPERSPY SCIENCE
SCIENCE, DEATH AND TECH IN THE WORLD OF JAMES BOND
KATHRYN HARKUP
WE ARE ELECTRIC
THE NEW SCIENCE OF OUR BODY'S ELECTROME
SALLY ADEE

EMAIL YOUR QUESTIONS TO **QUESTIONS@SCIENCEFOCUS.COM**

GETTY IMAGES X3 ILLUSTRATION: GHELEYNE BASTIAEN

DON'T MISS THIS EXCLUSIVE OFFER

CLAIM YOUR FREE ISSUE

Here is your chance to sample an issue of the world's best wildlife magazine absolutely free!

It's easy...

Simply scan the QR code to download your digital edition straight away or visit **try.discoverwildlife.com/springwatch24**

SCAN ME

BBC
wildlife
APRIL
2024
Issue 05 Vol 42
discoverwildlife.com
New hope for the northern white rhino
Spectacular condors in the Andes
The trophy hunting debate
10
ANIMALS THAT RULED BEFORE THE DINOSAURS
Sir David Attenborough's
MAMMALS
The inside story of the epic new BBC series
BBC ONE

Alternatively, subscribe today and get your first 6 issues for just £9.99!*

YOUR SPECIAL SUBSCRIPTION OFFER:

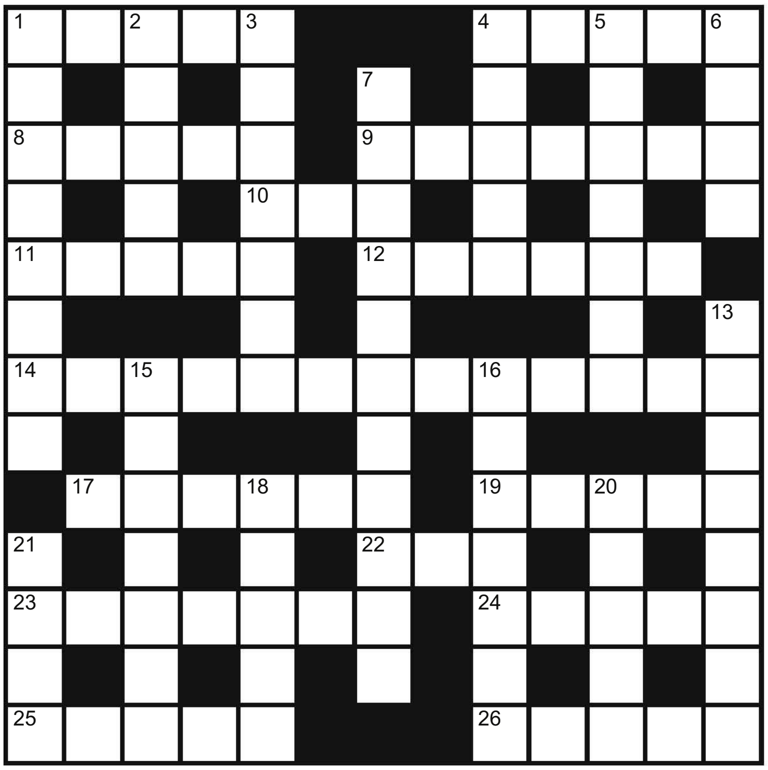
- Your first 6 issues for just £9.99*
- Continue to save at £19.99 every 6 issues thereafter
- Every issue delivered direct to your door
- Never miss an issue

Visit **www.ourmediashop.com/WLSP24HA**
or call **03330 162 114**† QUOTE CODE **WLSP24HA**

*Offer available to UK Direct Debit orders only and subject to availability. After your first 6 issues for £9.99 you will pay £19.99 every 6 issues saving 40% on the shop price. If you cancel within 2 weeks of receiving your 5th issue, you will pay no more than £9.99. This is an introductory offer and we reserve the right to reject or cancel any application for a trial subscription offer if the customer has previously purchased a trial offer for the same magazine or any other magazine in the Immediate Media portfolio. For a full list of our titles visit ourmediashop.com. Your subscription will start with the next available issue. +UK calls will cost the same as other standard fixed line numbers (starting 01 or 02) and are included as part of any inclusive or free minutes allowances (if offered by your phone tariff). Outside of free call packages call charges from mobile phones will cost between 3p and 55p per minute. Lines are open Mon to Fri 8am – 6pm and Sat 9am – 1pm.'

CROSSWORD

PENCILS AT THE READY!



ACROSS

1 Glorify old sailor? Not initially (5)
4 Buck's mates having small amounts of medicine (5)
8 Behold, behind church: large instrument (5)
9 Cleaning out – not new, but heavenly (7)
10 A great deal to find at the auction (3)
11 Puppets found on board? (5)
12 Not broken during diplomacy (6)
14 Filming line in practice area (8,5)
17 Savage has some champagne with a Liberal (6)
19 Mine volunteers some bread (5)
22 I will shortly be unwell (3)
23 Treated smile as random (7)
24 One transaction is perfect (5)
25 Sentences punishment? (5)
26 Restaurant or its client (5)

DOWN

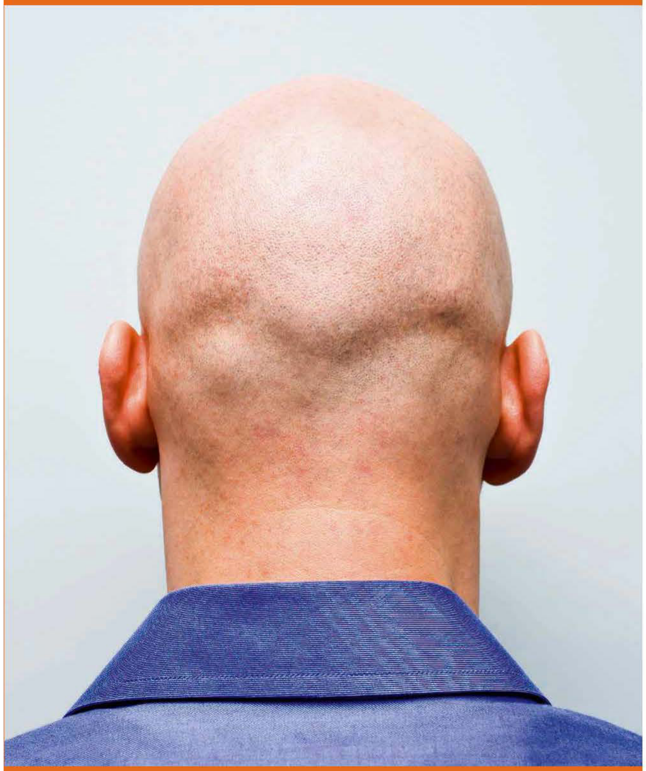
1 Aspect is strangely distracting from reality (8)
2 Radiant silver and blue (5)
3 Excessively regulated, having left group of software functions (7)
4 A number enjoy something (5)
5 Colin is regenerating semiconductor (7)
6 Poorly staff having time off (4)
7 Patriot people – top people (11)
13 Shopkeeper engineers follow with hesitation (8)
15 As Roman affected athlete (7)
16 Answered agent wasn't truthful (7)
18 Tries different layers (5)
20 Adolescent has right to antique wooden objects (5)
21 Note everything in resentment (4)

ANSWERS For the answers, visit **bit.ly/BBCFocusCW**
Please be aware the website address is case-sensitive.

NEXT ISSUE

KEEP YOUR HAIR ON

Just how close are we to finding a 'cure' for balding?



GETTY IMAGES

PLUS

HAPPY, BY DEFAULT

Why lottery wins and alloy rims won't change your outlook on life for long

CREATINE

Could the supplement that's beloved of bodybuilders have benefits for your brain?

ON SALE 9 JULY

SF

BETTER LIVING THROUGH SCIENCE

HOW TO SLOW TIME

Can we feel like we have more time by bending our perception of it?

by **IAN TAYLOR**
Ian is a freelance science writer and the former deputy editor of BBC Science Focus.

Tempus fugit: time flies. If it ever feels like your days are hurtling by in a blur of meetings, phone notifications and caffeine stops, know that you're not alone. That Latin phrase has its roots in the writings of Roman poet Virgil, a couple of millennia ago, after all. More recently, a survey last year found that six in ten people feel like they don't have enough time in the day to get everything done. 'Flies' doesn't quite cut it; time can feel like it's gone supersonic.

But new research from George Mason University in the US gives a hint of a much-needed deceleration. Neuroscientists there are studying time dilation, a phenomenon where your perception of time seems to stretch and slow down.

In their latest study, they're looking at whether certain images, experiences or scenarios are more likely to dilate time, and found that memorable images can play a kind of mind trick on you. The more memorable an image, the more likely you are to think you've been looking at it for longer than you actually have.

In the lab we're talking seconds, says Prof Martin Wiener, who led the research. "What it means is a moment appears longer to the observer than in reality," he says.

"Maybe we dilate time to get more information. It's a way in which the brain says, 'I'm seeing something and it's really important so I'd better dilate time to gather as much information as I can in this moment'."

That raises an intriguing prospect: can we mentally slow down time, learn to live more in the moment and stretch the good times out?

We know that the subjective perception of time is malleable. Common sense and age-old clichés tell us that much: time flies when you're having fun and slams the brakes on when you're clock-watching or waiting for a kettle to boil.

"The problem is, when we do feel like we have more time, it's often not a good thing," Wiener says. "Generally, when time drags on, those are moments that are upsetting or boring – time working against us."

Other factors can influence our perception of time, too. Loud experiences usually feel longer-lasting than quiet ones, while emotional or frightening images give the sense that you've looked at them for longer than more passive ones.

If you're an impulsive person or have ADHD, time might appear to pass more quickly than it does for other people. Then there's 'flow'; a state of mind usually described as being 'in the zone', when you're fully immersed in something you're also enjoying.

"Flow is an experience where time does seem to slow down a bit in the moment, but it's pleasant," says Wiener. "Meditation is an example. That's one of the cases where time does seem to dilate."

Wiener points out there's a difference between time in the moment and time as we remember it. "Time flies by in the moment, but when we look back on our memories, they seem to have lasted longer. If you go on vacation for a week to somewhere you've never been, when you look back on it, you might think, 'Wow, I did all this stuff?!'"

In our minds, a holiday feels like it lasts longer than a typical week, where our everyday routine flies by. Possibly our brains don't stop to absorb that information as much. "When we're experiencing the same old thing, experiences lack memorability," Wiener says. "And they lack time."

So how can we bend time to our will and give ourselves more of it – even just an artificial sense of slow-motion living? Wiener's research suggests that "seeking out interesting information, new and different, exciting and stimulating things is useful because it does dilate our sense of time, but it also improves our memory for those situations," he says.

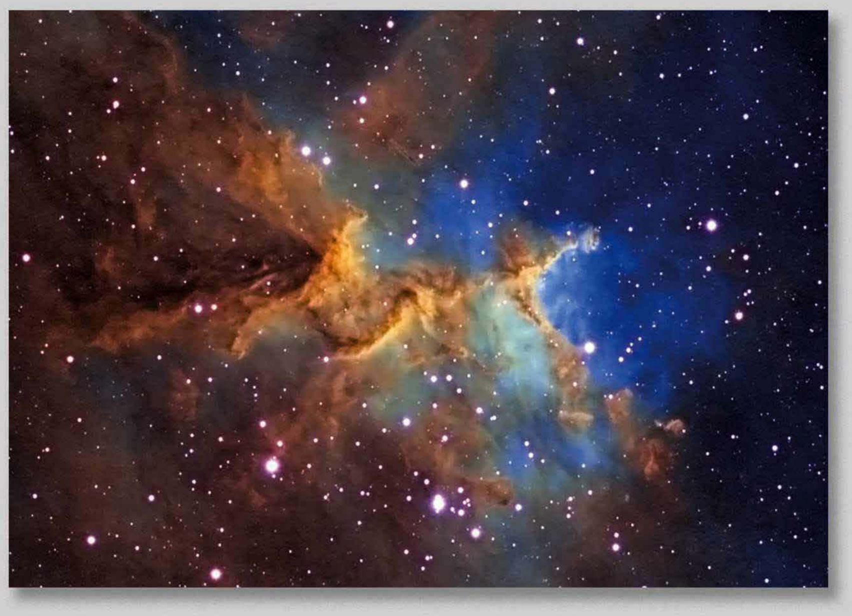
It's about new hobbies, seeing new places, throwing yourself into new subjects or meeting new people. In other words, if you want to experience more time, then you need to make more of the time that you've got. **SF**

"CERTAIN IMAGES, EXPERIENCES OR SCENARIOS ARE MORE LIKELY TO DILATE TIME; MEMORABLE IMAGES CAN PLAY A KIND OF MIND TRICK ON YOU"

ILLUSTRATION: EMANUEL SANTOS

GALAXY
ON GLASS

SPECTACULAR WALL ART FROM
ASTROPHOTOGRAPHER CHRIS BAKER



Available in Aluminium, Acrylic,
Backlit and Fine Art Prints.
Use the code: SPRING24 for a 20% discount.

www.galaxyonglass.com
chris@galaxyonglass.com | +44 (0)7814 181647

PCSPECIALIST

YOUR VISION.
OUR EXPERTISE.

Configure a new custom PC or laptop with the latest components from the biggest brands at

WWW.PCSPECIALIST.CO.UK

Get an exclusive **£15 discount** using code **BBF24**